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INFORMAL TECHNICAL REPORT

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Approvals:

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(Signatures on File)

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Prologue

This document, *STARS Conceptual Framework for Reuse Processes (CFRP), Volume II: Application, Version 1.0*, is Volume II of the two-volume STARS CFRP document set. It provides initial guidance in how to apply the STARS CFRP, as defined in the companion volume, *STARS Conceptual Framework for Reuse Processes (CFRP), Volume I: Definition, Version 3.0.*

Both CFRP volumes will be revised and re-released periodically to reflect the lessons learned in defining and applying the CFRP and to address comments from reviewers of the documents, both internal and external to STARS.

We thus encourage trial application of the CFRP and solicit reader review and comments as input to future revisions of both volumes. Please submit comments to:

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1 Introduction

This document was produced by the Software Technology for Adaptable, Reliable Systems (STARS) program on behalf of the U.S. Department of Defense (DoD) Advanced Research Projects Agency (ARPA). The document was developed by a STARS working group consisting of members from each of the STARS' prime contractor teams, the MITRE Corporation, and the Hewlett-Packard Company (a STARS Technology Transition Affiliate).

This document is Volume II of a two volume set. The other volume, *STARS Conceptual Framework for Reuse Processes (CFRP), Volume I: Definition, Version 3.0* [Sof93d], defines the STARS CFRP. Volume II directly supplements Volume I by providing initial guidance in how the CFRP can be applied. It is thus essential that Volume I be read before reading Volume II. It is also recommended that Volume I be readily available and consulted frequently as a reference while reading Volume II.

Throughout the remainder of this document, Volume I will often be referred to informally as the "CFRP Definition document", and Volume II will be referred to as the "CFRP Application document".

1.1 Purpose

The CFRP Definition document provides a complete definition of the abstract CFRP model. However, it provides little concrete guidance to assist someone in interpreting and tailoring the CFRP to support reuse program and project planning. The primary purpose of the CFRP Application document is to provide such guidance, in preliminary form, to potential users of the CFRP. A secondary document objective, through providing such guidance, is to promote further understanding of the CFRP and its underlying reuse concepts. A third objective of the document is to indicate how existing reuse processes and tools relate to the CFRP by mapping a representative sampling of such products to the CFRP families to which they apply.

1.2 Audience

This document is targeted to readers having one or more of the following roles in their organizations:

- *Program/Project Planner* – Responsible for planning the objectives, strategy, processes, infrastructure, and resources for software engineering programs or projects. Interested in incorporating domain-specific reuse into those programs or projects.
- *Process Engineer* – Responsible for defining, instantiating, tailoring, monitoring, administering, and evolving software engineering process models. Interested in defining reuse processes or integrating them with overall life cycle process models.
- *Reuse Advocate* – Responsible for keeping abreast of reuse concepts, technology, and trends and promoting the establishment or improvement of reuse capabilities and practices within an organization. Interested in understanding how new concepts and technology can be applied to accelerate reuse adoption.

Different portions of this document may appeal most strongly to one segment of the audience or another. However, the entire document should be of some interest to all readers, because all the audience segments are interdependent and each can benefit from the broad range of perspectives presented in the document.

1.3 Context and Approach

The CFRP has been developed and put forth to provide a process-oriented organizing framework for STARS reuse work and to articulate a set of common basic concepts underlying process-driven, domain-specific reuse-based approaches to software engineering. It is based on the STARS vision and mission, recent trends in organizational theory and management, and recent advances in reuse technology and practice. It reflects a consensus view of the authors, based on their own experience, feedback from individual reviewers and workshop working groups, and lessons learned through early CFRP application.

The CFRP has been applied in several limited ways to date and is now being applied more substantially by the STARS demonstration projects and STARS Reuse Technology Transition Affiliates. In these contexts, the CFRP is providing overall organizing principles and is supporting reuse project planning, life cycle process definition, and the selection and detailed definition of specific reuse-related processes. These trial applications have yielded, and will continue to yield, feedback that supports further evolution of the CFRP and additional understanding of how the CFRP can be applied in practice. However, the more ambitious and sophisticated of these CFRP application efforts are still in progress and the results are still largely undocumented.

In the absence of substantial documented experience in the practical application of the CFRP, it is premature to provide formal, definitive guidance for using the CFRP at this time. Instead, the first version of this document offers informal, suggestive guidance, primarily in the form of examples that illustrate how the CFRP can be used. The document includes a discussion of general CFRP application principles, a set of scenarios illustrating those principles in practice, a brief summary of experiences with the CFRP to date and an initial set of informal guidelines based on those experiences, an example process model that elaborates on the information flow among CFRP processes, and mappings between the CFRP and existing reuse products.

As a result of feedback from current and future CFRP application efforts, future versions of this document may include more definitive guidance, possibly including a well defined process or processes for applying the CFRP in various ways, supported by concrete, detailed examples and case studies.

1.4 Document Organization

This document is organized as follows:

- Section 1 (this section) provides introductory material that establishes the document context, purpose, audience, and approach.

- Section 2 presents general CFRP application principles, with brief descriptions of specific suggested types of usage, discussion of specific CFRP process modeling techniques, and examples illustrating those techniques.
- Section 3 includes four moderately detailed scenarios providing concrete, practical illustrations of different ways in which the CFRP can be applied.
- Section 4 summarizes experience with the CFRP to date and offers a brief set of preliminary guidelines for getting started with the CFRP.
- Appendix A provides a high-level CFRP process model, expressed in the form of $IDEF_0$ diagrams and an associated data dictionary, that shows one interpretation of the information flows among CFRP process idioms, families, and categories.
- Appendix B provides tables that map existing STARS and non-STARS reuse products to the CFRP process families to which they apply.
- The References section provides bibliographic entries for all documents referenced in this document.

2 CFRP Application Principles

The CFRP Definition document defines the CFRP as an abstract model consisting of a set of individual elements (reuse process idioms, families, and categories) and their high-level interrelationships. This section defines a set of general principles for how this abstract model can be applied in practice by planners, managers, and engineers involved in establishing and evolving reuse capabilities within their organizations. The section describes some general approaches for applying the CFRP, discusses a set of process modeling techniques that can be used in the CFRP context, and offers examples illustrating those techniques.

2.1 General Approaches for Applying the CFRP

Because the CFRP forms a strongly interconnected, cohesive system for describing and classifying reuse processes, it may appear to prescribe a particular approach to reuse. However, the CFRP is designed to be generic with respect to specific domains, organizational structures, economic sectors, life cycle models, detailed methods, and implementation technologies. While it captures the essential characteristics and interrelationships of domain-specific reuse-based software engineering processes, and thus is not "policy-free", it does not legislate beyond those essential qualities; it leaves decisions about the organization-specific details of reuse programs and processes to the CFRP user.

To the extent that the CFRP does prescribe an approach, it embodies certain concepts that add significant value relative to not only conventional software engineering practices, but also most current approaches to managed reuse. In particular, the CFRP explicitly emphasizes certain aspects of reuse that are often ignored or left implicit in most reuse approaches.

For example, several reuse process models (e.g., [BM91, Vir92a]) distinguish between domain engineering and application engineering groups within organizations, but they neither call out Asset Management as a logically distinct function, nor address the implications of bundling Asset Management functions with either Asset Creation or Asset Utilization. The CFRP could be used to describe a life cycle built in accordance with such a two-functioned model, but would force the explicit documentation of where within the overall organization Asset Management was being performed, and why.

Another distinctive aspect of the CFRP is its explicit recognition of the role of learning as fundamental to managed reuse. Few current reuse approaches (e.g., [BCC92]) treat learning processes explicitly or even acknowledge them as important. Most approaches either ignore the role of learning in reuse, address it implicitly in various ways, or just assume that reuse learning will happen as a result of institutional process improvement or quality assurance measures that are not directly integrated with reuse processes.

Because of these distinguishing CFRP characteristics, the use of the CFRP (e.g., in assessing and evolving existing reuse capabilities or establishing new capabilities) will often yield results that are qualitatively different from those that would be produced using an ad hoc approach or other reuse-oriented approaches.

Some of the specific ways in which the CFRP can be used include:

Reuse assessment and classification

The CFRP can be viewed as a descriptive domain model of reuse processes. It can thus be used as a kind of standard against which to assess and classify software engineering products in terms of the reuse processes they reflect or support. Such products could include process models or descriptions, program or project plans, project results, tools, assets, and so on.

For example, organizations can use the CFRP to assess their current software engineering practices and infrastructure to help them understand the strengths and weaknesses of their current reuse capabilities. Similarly, they can use the CFRP to assess proposed plans, processes, and tools for completeness and consistency. Organizations can also use the CFRP to communicate the characteristics of reuse products or capabilities to others by classifying them in terms of the CFRP families or categories they address.

Reuse program and project planning

The CFRP can support planning in a variety of forms and at a variety of levels. In general, the CFRP plays two key roles in planning: (1) To guide the reuse planning process itself, and (2) To give planners information about the reuse-relevant activities they are planning. The CFRP can impact the planning of specific activities in significant detail, but it can also have impact simply by conveying a general set of reuse-oriented principles.

The CFRP can be useful in high-level strategic planning by, for example, providing insight into the role reuse can play in long-term investment strategies and indicating how reuse can help build competitive advantage. The CFRP can directly assist reuse program planners by guiding their planning processes and by giving them a framework for flexibly structuring reuse programs in terms of the CFRP idioms and families. The CFRP provides the project planner with similar assistance, typically more at the process category level, by giving the planner insight into specific reuse activities that need to be performed. Such assistance scales down to the level of the individual engineer, as well, who can use CFRP concepts and principles to help plan his or her daily work.

Reuse process engineering

The CFRP can be viewed as a high-level process model. It defines a set of generic process elements and provides significant information about how those elements interrelate. The CFRP can thus be very useful to process engineers who are interested in defining or modeling reuse processes and their interactions. The CFRP can also help with integrating reuse into overall life cycle processes by providing a general set of Asset Utilization process categories that is readily adaptable to any life cycle product or phase.

In addition, the CFRP addresses process issues from a different perspective by defining a generalized approach to process (and product) improvement via the Reuse Management idiom. The CFRP may thus be of interest to process improvement groups within an organization because of its integrated approach to planning, learning, metrics, innovation, and infrastructure.

The use of the CFRP in any specific context should reflect the needs and circumstances of the organization(s) in which it is being applied. For example, an organization needn't embrace all aspects of the CFRP at once. It may make sense in many organizations to adopt reuse in a gradual

fashion, by limiting the scope of initial reuse-based projects (e.g., by assuming assets are created outside the organization, and thus not sponsoring internal Asset Creation projects) or by phasing CFRP Reuse Management processes into the organization's overall way of doing business in an incremental fashion over a period of time.

2.2 CFRP Process Modeling Techniques

The CFRP can be applied in a number of useful ways without taking full advantage of its inherent flexibility and adaptability. However, when the CFRP is used as a basis for process modeling, as is often the case in a planning or process engineering context, the full benefits of the CFRP can only be achieved by understanding and applying some or all of the following CFRP modeling and adaptation techniques:

- *Tailoring* of CFRP process categories so that they will be applicable in some specific context
- *Composition* of CFRP process idioms and families to produce arbitrary CFRP-consistent process configurations
- *Integration* of CFRP elements with other process elements to form new process models, typically with broader life-cycle coverage
- *Instantiation* of process elements via allocation to organizational entities

The following paragraphs discuss these techniques in more detail.

Tailoring

The CFRP process categories, as defined in the CFRP Definition document, may not be entirely applicable in some organizational contexts. While many processes in an organization might correspond clearly to specific CFRP categories, other organization plans or processes may justify addition of new process categories. These will typically involve categories that are believed to be reuse-specific, but are not included in the current CFRP. Alternatively, all of the categories within one or more CFRP families could be reconfigured or repartitioned to reflect different perspectives on reuse within the organization. In addition, any categories deemed inappropriate could be eliminated or modified. These kinds of adjustments to the CFRP process category structure are collectively called CFRP "tailoring". Such tailoring could be done anew each time the CFRP is applied, or modelers could create a persistent tailored version of the CFRP incorporating a variety of organization-specific assumptions, which could then be reused as the basis for future CFRP-based process modeling activities within the organization.

As noted in the CFRP Definition document (in the introductory portion of the CFRP Description section), the CFRP process idiom and family structure is considered fundamental to CFRP semantics, whereas the categories are viewed as more arbitrary, and thus more adaptable. The CFRP tailoring techniques are thus generally applicable only at the process category level, since they focus on adding, modifying, deleting, and repartitioning CFRP elements.

Composition

Although the tailoring techniques are useful for adapting CFRP process categories to organizational needs, greater expressive power is needed to configure the CFRP idioms and families to reflect sophisticated reuse-specific process interactions. This power is provided by the CFRP composition techniques (e.g., linkage, recursion, cascading), which enable the idioms and families to be connected together to produce arbitrary CFRP configurations. Such configurations can represent a wide range of interesting relationships and interconnections among CFRP elements. The composition techniques are considered an intrinsic part of the CFRP model, and are thus described in detail in Appendix A of the CFRP Definition document, rather than in this document.

CFRP configurations can represent models ranging from the very concrete (a project plan involving specific organizations, individuals, and processes, interacting in specific ways) to the relatively abstract (a reuse process model that standardizes certain recurring processes and policies, but must be integrated with a life cycle model and instantiated for each project). For example, an organization that wants to establish a separate Asset Management effort to manage each major type of asset in its software life cycle (i.e., establish distinct libraries for reusable requirements, designs, code, test cases, etc.) might develop a generic CFRP configuration reflecting this policy. Individual Asset Creation or Asset Utilization (i.e., application engineering) projects would then integrate and instantiate this organization-wide model within their project plans.

Integration

Since the CFRP contains only process elements relevant to reuse, these elements must be integrated with non-reuse-specific processes to form overall life cycle process models. This integration can be approached in either (or often both) of the following complementary ways:

- embedding non-CFRP processes within a CFRP process model, or
- embedding CFRP processes within an existing non-CFRP process model.

As an example of the first approach, existing validation and verification processes that are applied throughout the organization in a single-system context could be integrated with Asset Creation processes to impose organization-standard V&V procedures for created assets. Another example of the first approach, from the Reuse Management perspective, is that any engineering process could be enacted using the CFRP Plan-Enact-Learn paradigm. In this sense, the Reuse Management idiom can aid in planning, enacting, and deriving lessons learned from any engineering process.

As an example of the second approach, Asset Utilization processes could be embedded within the various steps of an existing application engineering life cycle to effect reuse in each life cycle stage in ways that are appropriate for the domain and for the system being engineered.

In either of the above integration approaches, the processes with which the CFRP is being integrated should be analyzed to identify overlaps and gaps relative to the CFRP, to help guide the integration process. This analysis and the subsequent integration should be subject to certain CFRP constraints. In particular, each CFRP idiom and family should appear in the integrated process, or their absence should be explicitly justified (e.g, by acknowledging that the processes in one or more of the Reuse Engineering families is being performed outside the organization). The

Reuse Learning and Asset Management families are important, distinctive CFRP features, and inclusion of these functions is a recommended CFRP modeling constraint.

Instantiation

The CFRP is designed to make minimal assumptions about where organizational boundaries might fall within or between idioms and families. The intent of the idioms is to capture essential aspects of a reusable engineering process that remain invariant whether that process is enacted by a single individual, a single organization, or a collection of interacting organizations.

Thus, to make a CFRP model fully applicable within an organization, each idiom or family must be "instantiated" to represent performance of the CFRP functions by an individual worker, project team, or larger-scale organization. A single organizational unit may take responsibility for the processes encompassed by several CFRP families. Alternatively, the functions of one CFRP element can be distributed across different organizations, different divisions within an organization, or different individuals in a small development group (depending on the level at which the CFRP is being applied). For example, the CFRP could be applied to an organization that maintains a single large asset base serving multiple domain-oriented reuse projects, or to an organization that decides to maintain separate asset bases for reusable assets from different parts of the software life cycle. As an example of family interactions that can be distributed across scopes of planning, one organization can create assets, a second organization can manage those assets (and perhaps other assets from a variety of sources), and a third organization can utilize those managed assets.

If the process model being instantiated includes non-reuse-specific elements (resulting from application of the CFRP integration techniques discussed above), the instantiation operation should generally be applicable to both the reuse-specific and non-reuse-specific elements of the model.

2.3 CFRP Process Modeling Examples

To put the above techniques in more concrete terms, two examples are presented below.

Figure 1 illustrates a high-level process model that reflects CFRP tailoring and integration techniques. The model is divided into separate Domain Engineering and Application Engineering life cycles (forming a so-called "dual life cycle" model). Intervening between the activities in the respective life cycles is an Asset Management layer, in which no specific activities are identified. (Note that the diagram leaves other aspects of the model unspecified, as well. For example, no flows of information indicating feedback or learning are shown explicitly.)

The Application Engineering life cycle illustrates CFRP integration, because the implication in the diagram is that Asset Utilization processes are integrated with (specifically, embedded within) conventional life cycle activities to ensure that assets created by the indicated Domain Engineering activities are reused when constructing applications. The Domain Engineering life cycle illustrates CFRP tailoring, because the CFRP Domain Analysis, Domain Architecture Development, and Asset Implementation process categories are tailored specifically to create assets to be reused by a corresponding set of Application Engineering life cycle activities. In particular, Domain Analysis is tailored to produce requirements assets (or at least requirements guidance) for the application analysis activity, and Asset Implementation is tailored to focus specifically on code component

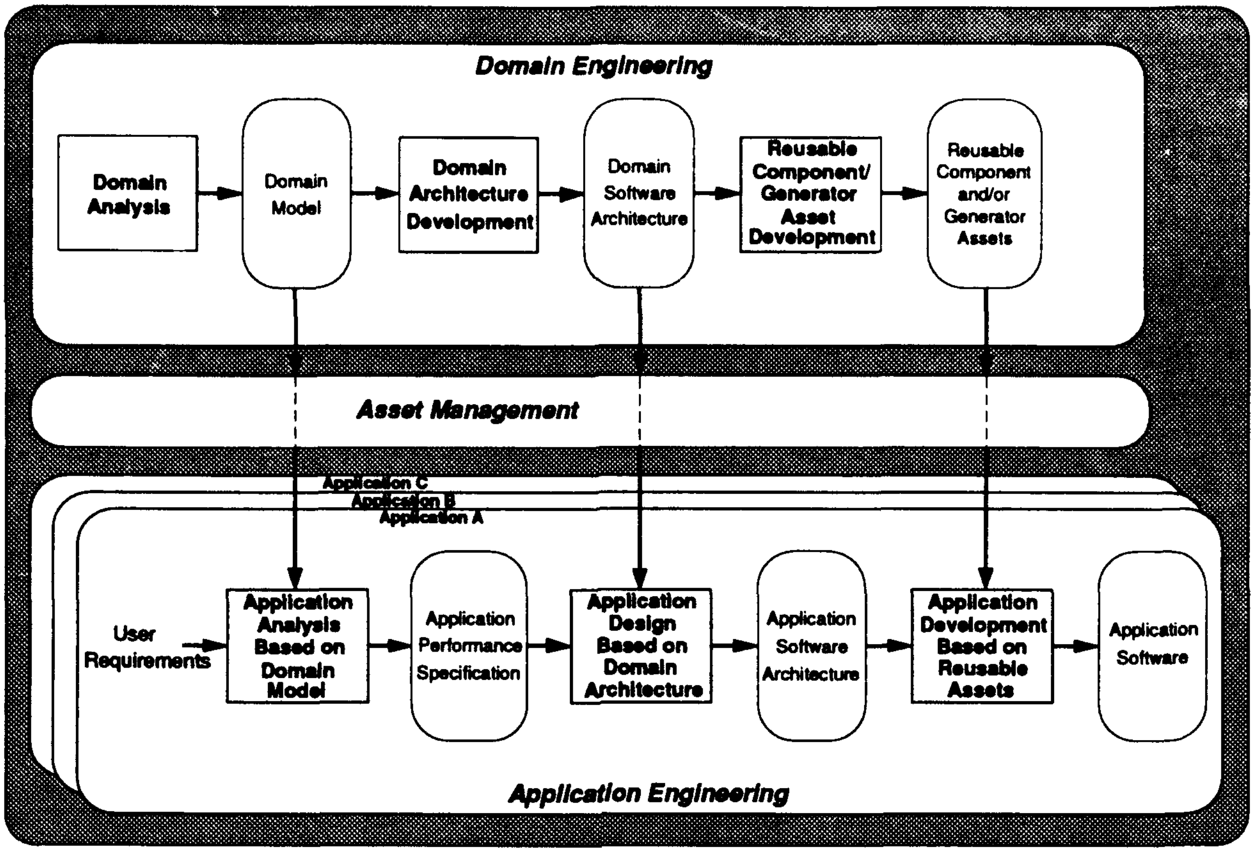


Figure 1: Example of CFRP Tailoring and Integration Techniques

and generator development. Of the three Domain Engineering activities, Domain Architecture Development appears to be interpreted most consistently with its corresponding process category description in the CFRP Definition document.

Figure 2 shows a different view of the same situation depicted in Figure 1, reflecting the use of CFRP composition and instantiation techniques. The diagram illustrates CFRP nesting/recursion techniques by showing:

- an outer Reuse Management idiom representing a high level reuse program,
- a set of Reuse Management idioms defined recursively within the outer idiom, each representing lower level scopes of planning responsible for Domain Engineering, Asset Management, and Application Engineering, respectively, and
- a set of Domain Engineering (Asset Creation), Asset Management, and Application Engineering (Asset Utilization) projects nested within the inner Reuse Management idioms, each performing the appropriate processes depicted in Figure 1.

CFRP linkage techniques are shown by the arrows connecting the Asset Creation, Management, and Utilization activities to identify the general flow of assets within the reuse program.

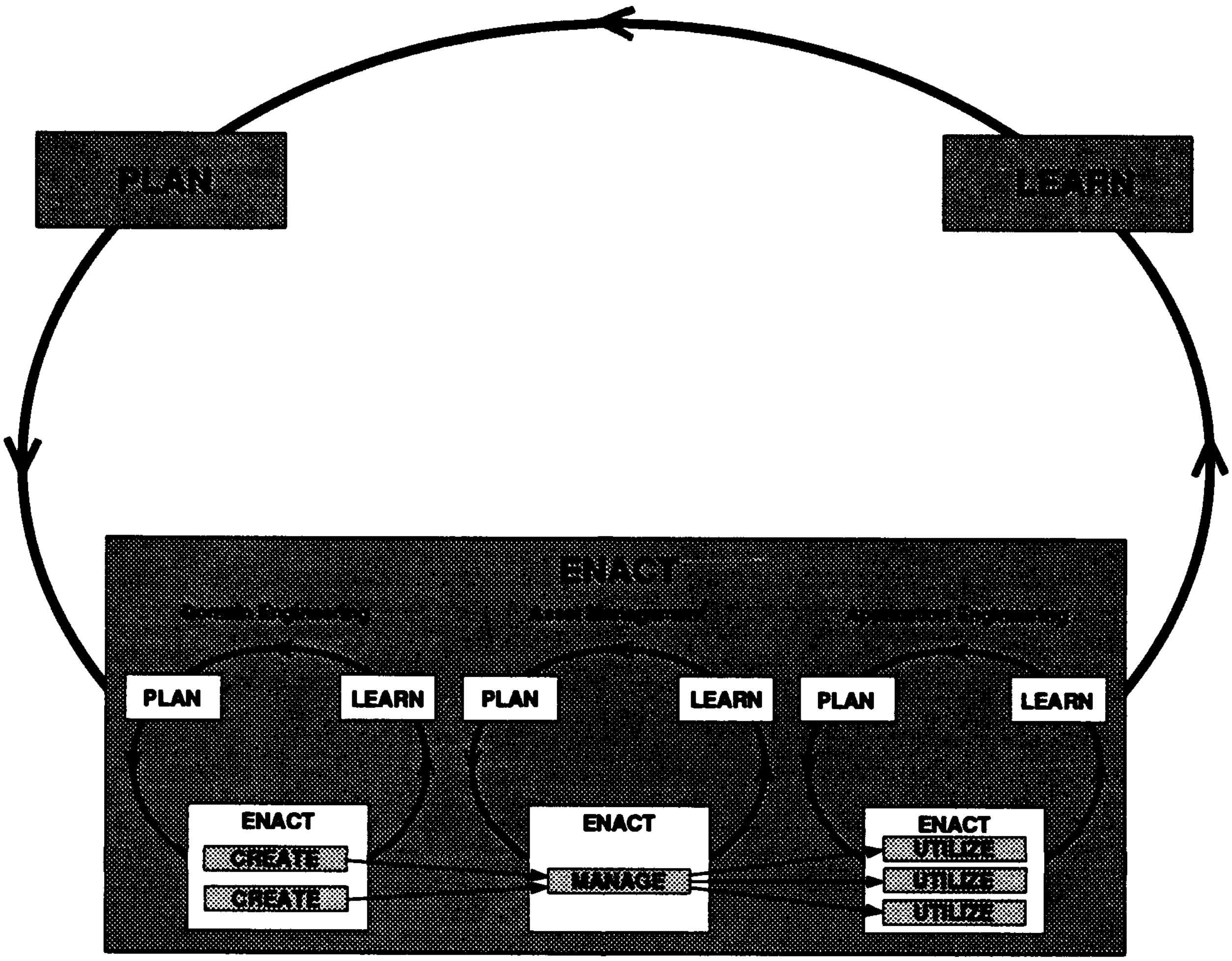


Figure 2: Example of CFRP Composition and Instantiation Techniques

Although the diagram contains no organizational labels, it can readily be interpreted as an instantiation of the CFRP representing the hierarchical organizational structure of an overall reuse program. The outer Reuse Management idiom in this example represents a reuse program at the division level within a company. The inner Reuse Management idioms represent departments within the division, responsible for managing groups of projects performing distinct kinds of Reuse Engineering activities. The Reuse Engineering families in the diagram represent distinct project organizations within the departments, focusing on particular domains, libraries, and applications.

Appendix A provides a different kind of CFRP process modeling example, using the $IDEF_0$ notation. This model offers one interpretation of the data flows among CFRP idioms, families, and categories, consistent with the canonic CFRP described in the CFRP Definition document. Organizations can use this model directly as a basis for additional $IDEF_0$ CFRP modeling (e.g., modeling the CFRP in more detail or modeling alternative CFRP configurations). They can also tailor the model by developing alternative interpretations of the process categories and data flows, or they can integrate the model (or any tailored version thereof) with existing $IDEF_0$ process models.

3 CFRP Application Scenarios

This section presents four scenarios that illustrate the use of the CFRP in several practical contexts. The scenarios provide examples of how the CFRP can be used to influence the nature of reuse-oriented software engineering activities and support various types of planning and management tasks. The scenarios are presented here not to provide greater detail about the CFRP than appears in the CFRP Definition document, but rather to make it more accessible and relevant to software engineering practitioners. The scenarios are meant to show the reader how it "feels" to apply the CFRP. They are *not* intended to be general prescriptions or recipes for CFRP usage. Although the scenarios are concrete, in that they refer to specific methodologies and tools and include planning choices, they are not intended to reflect the "right" selections or choices in general.

This section includes: (a) an overview of the scenarios that defines their overall context and describes their general format, (b) the four scenarios, and (c) a review and analysis of the scenarios in terms of how they communicate key CFRP concepts.

3.1 Scenario Overview

The scenarios in this section illustrate several different ways in which the CFRP can be applied and reflect several different circumstances under which it can be applied. The scenarios elaborate on some of the CFRP uses that were discussed in Section 2. Two scenarios show the use of the CFRP to support planning, one scenario depicts the use of the CFRP to support the definition of reuse-oriented application engineering processes, and one scenario illustrates the use of the CFRP as a mechanism for understanding and evaluating an existing reuse plan.

To help establish a context for the scenarios, recall that the CFRP Definition document defines a reuse program as the set of activities encompassed by (and including) a particular instance of the Reuse Management idiom. Each reuse program has a scope of planning that includes a set of interconnected reuse projects and infrastructure activities operating in the context of a set of selected domains. A reuse project is any project (typically involving activities from one or more of the Reuse Engineering process families) that is enacted by Reuse Enactment processes. Figure 3 shows the Plan-Enact-Learn loop of a reuse program and, within the Enact box, three P-E-L loops representing Asset Creation, Management, and Utilization projects. The figure locates the four scenarios in terms of planning level or scope and in terms of the CFRP families to which they most directly apply. The figure is not meant to imply that the scenarios are all telling related stories within the same reuse program context; it merely indicates which aspects of the CFRP each scenario is addressing, and at what planning level. Some scenarios include activity in multiple families; in those cases the location indicated is the family where the scenario activity is primarily focused.

Scenario 1 suggests one way in which the CFRP can be used as a template or model (a "yardstick") for understanding, characterizing, and evaluating a reuse plan that was developed outside the CFRP context. Figure 1 shows this scenario occurring in the Learn box of the high level P-E-L loop (shown by a circled 1 in the figure pointing to that box). This is because it involves using the CFRP as an instrument to evaluate and learn about other reuse plans and also because it directly illustrates CFRP learning processes.

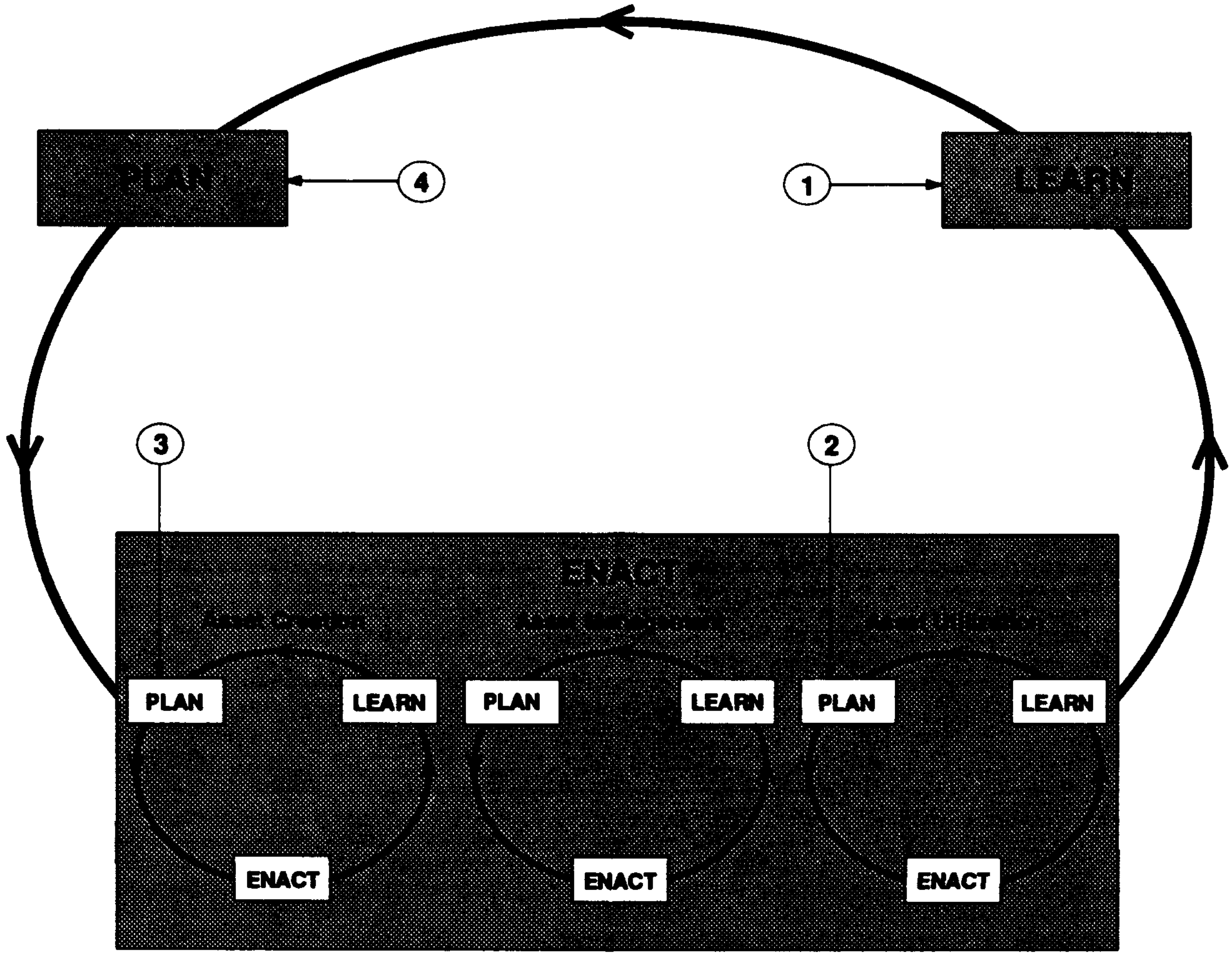


Figure 3: Scenario Location

Scenario 2 illustrates the use of the CFRP in guiding the definition of an application engineering process that incorporates reuse. It describes a process engineer integrating Asset Utilization processes into an organization's application engineering process. This scenario's location is depicted as the Plan box of the Asset Utilization P-E-L loop because it focuses on detailed planning activities associated with the definition of project processes that incorporate Asset Utilization. Note that it may also be valid to view this scenario as describing Infrastructure Implementation within the top-level Enact box in the figure, where the infrastructure in this case is a process model that will be applicable to more than one application engineering project within the reuse program.

Scenario 3 describes the use of the CFRP for planning a single project in the context of a higher level reuse program plan. The project being planned is an Asset Creation project, so the scenario is located in Figure 3 in the Plan box of the Asset Creation P-E-L loop. This scenario involves definition of a new domain analysis process model that is applicable across multiple projects, so it is comparable to scenario 2 in that it can also be viewed as describing Infrastructure Implementation processes.

Scenario 4 addresses the application of the CFRP to the high level planning of a domain-specific reuse program during the preparation of a proposal. Therefore it is located in the Plan box of the

1.	A reuse-based approach to software engineering should be driven by well-defined, repeatable processes.
2.	Software reuse has both management and engineering dimensions, whose activities are captured in the CFRP idioms.
3.	CFRP process categories provide a definition of the activities involved in a process-driven, domain-specific reuse-based approach to software engineering.
4.	Reuse should be applied as a "first principle"; that is, reusable products should always be considered as the basis for work before creating new products; experiences, processes, and workproducts should always be recorded for learning and for possible reuse.
5.	Measurement, learning, and managed change are essential and pervasive in reuse.
6.	Infrastructure is important to reuse and must be designed to support it.
7.	A domain-specific, architecture-driven approach to reuse is important, from both an engineering and a management perspective.
8.	The asset producer, broker, and consumer roles are distinct within Reuse Engineering.
9.	The CFRP is generic with respect to domains, technologies, management styles, and economic sectors.
10.	CFRP processes should be integrated with overall planning and engineering practices.
11.	The CFRP is a process modeling language with mechanisms to support composition of complex process configurations.
12.	The CFRP is scalable and applicable at different organizational levels.
13.	The CFRP is a domain model and high level process architecture for the reuse process domain; it provides a basis for the analysis of reuse processes and the definition of reusable process assets.

Table 1: CFRP Themes

high level P-E-L loop.

Each scenario presents a single narrative thread, describing a sequence of activities undertaken to accomplish some goal. In general, when a decision is made by an individual in the scenario, only the activities that result from that decision are subsequently described; the activities that would have resulted from a different decision are not discussed. Because one of the goals has been to keep the scenarios reasonably concise, some logical activities along even the single thread path may be omitted.

Scenario Themes

The CFRP Definition document, in its Summary section, identifies a set of central concepts, or themes, that are inherent to the CFRP. These themes are summarized in Table 1. Some of the themes convey messages about reuse that are contained in the CFRP, while other themes relate to characteristics of the CFRP itself. The scenarios are designed to illustrate these themes to varying degrees, and the themes are used as a basis for analyzing the scenarios in Section 3.6.

Scenario Assumptions

The following assumptions apply to all the scenarios:

- The individuals performing the scenarios and the organizations of which they are a part are in the process of transitioning to a process-driven, domain-specific reuse-based approach to software engineering.
- The individuals performing the scenarios are familiar with the CFRP Definition and Application documents. Both documents are implicit inputs to each scenario.
- No well defined and documented processes exist for applying the CFRP.

Scenario Format

The scenarios conform to a common outline, as follows:

- **Point of View** presents the viewpoint of the individual performing the scenario in CFRP terms.
- **Context** includes three subparts that establish the background for understanding the scenario:
  - **Setting** identifies the individuals performing the scenario, places them within their organization, and describes the situation in which they are operating.
  - **Goal** states the end towards which the activities in the scenario are directed.
  - **Assumptions** indicates any relevant assumptions in addition to the general scenario assumptions listed above.
- **Inputs** lists the inputs to the scenario activity.
- **Outputs** lists the products of the scenario activity.
- **Scenario Activity** provides the narrative description that is the heart of the scenario.
- **Commentary** concludes the scenario with a review of significant points, such as how the CFRP was applied in the scenario, how the themes were carried through by the individuals, or what insights can be gained from the scenario.

3.2 Scenario: Using the CFRP as a Yardstick

Point of View

This scenario describes the activities of a reuse advocate who has been tasked to evaluate a reuse plan developed by another division within her company.

Context

- **Setting**

  Jane is a staff technologist and reuse advocate in the Federal Systems Group (FSG) of Acme Corporation. Another division in the corporation, Financial Products Division (FPD), has requested that Jane review and comment on their latest draft plan to institutionalize reuse within their business processes. FPD's reuse implementation plan is in response to a mandate from Acme Corporation headquarters that they adopt reuse as a strategy to increase their productivity. The team (Dan, Bill, and Adam) that has assembled FPD's plan contacted Jane in the hopes of having her identify inconsistencies, ambiguities, and deficiencies in the plan that may have resulted from their reuse inexperience. Jane has agreed to do the review as an extension of her responsibility as a reuse advocate.

- **Goal**

  The goal of this scenario is to review FPD's reuse implementation plan to evaluate how well the plan implements and supports reuse-based activities. The CFRP, as a domain model of reuse processes, will be used to establish criteria for the evaluation.

- **Assumptions**

  - Jane is very familiar with both CFRP documents. She has applied the CFRP several times to assist in formulating long term reuse strategies within her own division and to review reuse implementation plans or business process improvement plans for other divisions that her organization supports.
  - Jane has conducted several CFRP orientation sessions for FPD, one of which Dan, Bill, and Adam attended. She also provided copies of the CFRP documents to FPD.

Inputs

The inputs include:

- FPD's Reuse Implementation Plan
- FPD's Business Planning and Strategy documents
- RedLine Process Description

When Jane agreed to FPD's request, she asked that, in addition to the draft reuse plan, they send her copies of their most recent business plans and Acme's directive mandating that they institutionalize reuse.

Jane plans to perform the review using the guidance of RedLine, an adaptable process description that Jane's division has adopted for structured review of documents. RedLine was created to integrate CFRP reuse principles and general process improvement principles into the standard document review practices of Acme. A summary of the steps in RedLine is:

1. Identify and assemble needed material
2. Read/Scan all assembled material
3. Define process objectives and review criteria
4. Analyze against criteria
5. Write up recommendations/results
6. Reflect on process/products

Outputs

The outputs include:

- Review Comments memo, including improvement recommendations
- Process metrics
- Product metrics

As she has done with previous reviews of reuse plans, Jane intends to produce a memo detailing her review comments, which will include selected pieces of the working material she produces. In addition to specific recommended changes to the draft plan, other candidate items to include are: a classification of the activities in the plan in terms of the CFRP process idioms, families, and categories; and diagrams showing the producer (asset creator), broker (asset manager), and consumer (asset utilizer) relationships found in the plan.

RedLine recommends the definition and collection of metrics both for tracking process improvement and productivity and for predicting resource and duration estimates in subsequent uses of RedLine. This prediction feature results from treating process historical data as a reusable asset. Thus, it can be assumed that throughout the scenario Jane collects measures such as page counts, material type (document, memo, diagram), and effort expended as she completes each RedLine step. Further, it can be assumed that Jane adds this data to her personal process asset library, where she manages process descriptions and history.

Scenario Activity

Jane starts by briefly reviewing the RedLine process description and notes the influence that the CFRP has had on the process, as reflected by its emphasis on the following:

- basing planned activity on previous experience
- using previously created material where possible
- reflecting at the end of each task on the reusability of newly created material
- reflecting at the end of each task or activity on improvements to the process and products

As a result, Jane realizes that this reuse plan review will not only use the CFRP as a basis for evaluating the plan, but will itself embody the CFRP in many ways through application of the RedLine process. With this in mind, Jane begins the process.

Step 1: Identify and Assemble Needed Material

As a first step, Jane identifies the business strategy documents, the CFRP documents, and the reuse plan to be reviewed, and collects all this material at her desk.

Step 2: Read/Scan All Assembled Material

Next, the RedLine process recommends reading all the material that is new and re-reading any additional material that may provide a basis for the review criteria. The process suggests marking all passages that should be revisited in more depth later.

Jane decides to start by reading the RedLine process description once all the way through before reading the other documents. She has used RedLine before, so re-reading the process description gives her an opportunity to improve her understanding of the process.

Next, Jane reads through the CFRP documents. Since she is planning to carefully analyze the process diagrams in the FPD plan, she spends most of her CFRP review time inspecting the following diagrams that describe information flows within and among the CFRP process families:

- CFRP Definition document:
  - The diagram in the Section 3 introduction that depicts the entire CFRP with its overall inputs and outputs and shows the general paths of information flow among the families.
  - The diagrams within the individual process family description sections that show the inputs and outputs for each family.
  - The diagrams in Appendix A that show various potential information flows and interrelationships among organizations or workgroups having different responsibilities for reuse-based development.
- CFRP Application document:
  - The diagram in Section 2 that shows high-level information flows among activities in a "dual life-cycle" process model.

- The $IDEF_0$ diagrams in Appendix A that show one interpretation of the information flows among the categories within each family.

After reading the CFRP documents, Jane scans the FPD reuse implementation plan and business strategy material. While she reads, she adds indexing markers to the passages that she believes will be most relevant to her evaluation.

Step 3: Define Process Objectives and Review Criteria

Jane is now ready to define the "process objectives" (i.e., the objectives that will be used to evaluate how well the RedLine process is performed) and the detailed "review criteria" (i.e., the particular measures or standards against which the reuse plan will be evaluated during the RedLine process).

RedLine recommends that the process objectives be expressed in terms of quantifiable quality measures that the review output must meet or exceed. Jane looks over the recommendations that she made to herself the last time she applied RedLine and decides to reuse two of them as the process objectives:

1. All conclusions are backed up with citations to relevant portions of the CFRP or relevant Acme policy and strategy documents.
2. There is at least one comment per numbered section, figure, or table in the plan.

Jane next identifies the review criteria for FPD's plan. Jane writes down several criteria that pertain to FPD's business planning, and also indicates several aspects of the CFRP that will be used as criteria. For example, she expects the reuse plan to include one or more elements corresponding to each of the CFRP process families, or to at least include rationale for why such elements are missing. Although Jane does not believe that every reuse plan should incorporate elements corresponding to each CFRP process family, she does believe that until reuse has become institutionalized within her company, each plan should provide evidence that the appropriateness or utility of each process family has been considered.

Step 4: Analyze Against Criteria

The heart of the RedLine process is to analyze the plan relative to the defined criteria. RedLine here offers general guidelines for evaluating consistency, clarity, and completeness, which Jane knows are intended to be adapted to the specific type of material being reviewed. As a basis for this analysis, Jane turns to the CFRP documents, as she planned, and focuses particularly on the diagrams that describe CFRP information flows, which she had examined in step 2 above.

In further studying these CFRP diagrams, Jane recalls that the reuse implementation plan under review contains a diagram entitled "Revised FPD Software Business Process". This diagram (as annotated by Jane) is included in Figure 4. Jane proceeds to classify each process box in the diagram in terms of the CFRP families and categories; her final classification is shown at the bottom of the figure. Jane bases her classification on the titles in the boxes, the description of each box in the plan's text, and the flows shown in the diagram.

In performing the classification, Jane initially classifies each box in terms of the one or more CFRP families to which it most clearly maps. Jane finds that such classification is not always

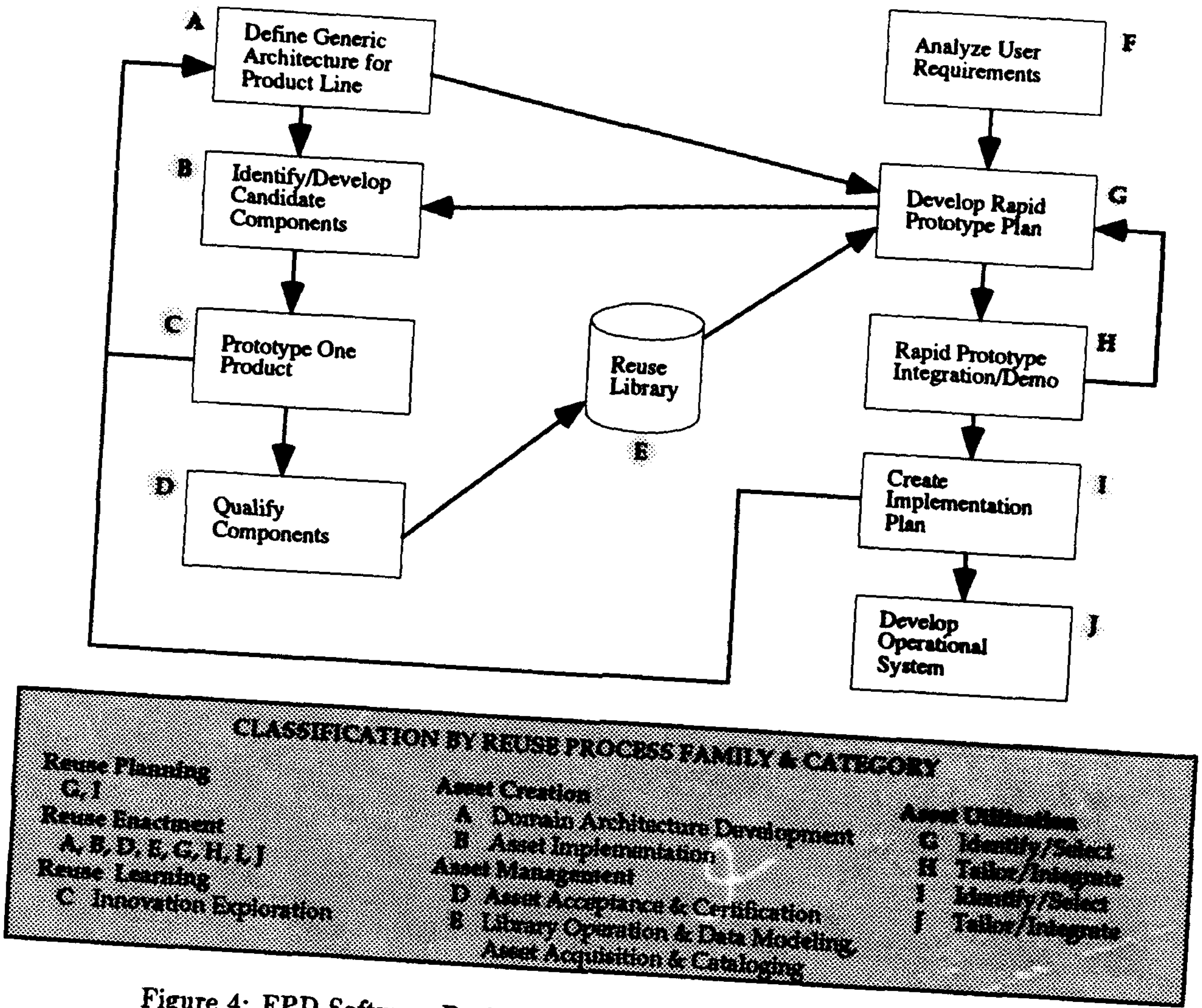


Figure 4: FPD Software Business Process Classified in Terms of the CFRP

straightforward. For example, although Jane's initial inclination is to classify process C in the Asset Utilization family, the text makes clear that the process's real purpose is to evaluate the architecture and components for their general applicability as well as to explore alternative approaches and technologies. Jane therefore decides that the process is most properly classified in the Reuse Learning family.

Also, Jane initially classifies processes G and I in the Reuse Planning family, but after closer inspection she realizes that they also address aspects of Asset Utilization because they perform identification and selection of assets that will be reused when developing the prototypes and operational systems. Jane thus classifies these processes in both the Reuse Planning and Asset Utilization families.

Next, Jane refines her classifications down to the CFRP process category level. Since each box has already been mapped to one or more process families, Jane compares each box to the process categories within those families. She finds that process A does not include any domain modeling activity, so she decides to recommend that another process be added prior to A that will produce a

domain model of the requirements for the business area. She also finds that the planning aspects of processes G and I are not described in enough detail to enable classification in specific categories. In general, Jane finds that no Reuse Planning categories and few Reuse Learning categories are described explicitly in the text.

Jane then compares the information flows in the diagram to the flows in the STARS CFRP diagrams, both to assess the validity of the flows and to identify specific Create-Manage-Utilize (C-M-U) and Plan-Enact-Learn (P-E-L) idioms. Since the flows are unlabeled, Jane makes some assumptions about their nature based on supporting information she finds in the text. One of the conclusions she reaches is that although one FPD business objective is to buy as many off-the-shelf components as possible, no flow of such components is shown in the diagram nor is any mentioned in the text.

Janc also notices that process F does not include any analysis of the generic architecture to help establish requirements. Jane believes this is an important aspect of domain-specific reuse-based software engineering, so she formulates a recommendation that the process be changed to include such an analysis.

On a positive note, the generic architecture and existing components in the reuse library are inputs to the development of the rapid prototype plan (process G). She assumes that, since the rapid prototype is an input to the development of the operational implementation plan (process I), the operational system is also developed using the generic architecture and components.

As a result of her analysis, Jane finds two distinct C-M-U idioms ([A, B, D, E, G, H] and [A, B, D, E, I, J]) and no complete P-E-L idioms. The first C-M-U idiom produces rapid prototypes; the second produces operational systems. Jane finds that the feedback flows needed to "close the loop" for potential P-E-L idioms are incomplete. In particular, there is no direct feedback from process J to process A, although there is feedback from process I (the planning and early utilization activity). In addition, there are no specific activities identified to learn from the feedback. In other words, processes I and J provide the Plan and Enact parts of a P-E-L idiom, but the Learn part is at best only vaguely specified.

Jane decides to consult the text in more detail to see if it describes any P-E-L idioms that are not apparent in the diagram. She finds that the individuals responsible for planning are identified, but the process steps for planning are not discussed in any detail, and no metrics are identified. She also verifies her earlier concern that, although feedback appears on the diagrams, there are no explicit activities to respond to it. There is only one activity (the technology exploration activity identified above) that explicitly addresses learning in any form. Jane writes a recommendation that the next draft of FPD's plan specifically address these issues.

Step 5: Write Up Recommendations and Results

Jane next must package her recommendations, conclusions, and observations into their final form and send them to the authors of the plan. RedLine recommends that a summary be produced that highlights the major conclusions of the review, with the detailed comments and supporting material packaged separately. While she is packaging her results in this format, Jane notices that some of her comments are really questions that she would want to consider about any reuse implementation plan, so she collects and saves these questions separately.

After she has completed the packaging, she sends the material to Dan, Bill, and Adam in both

hardcopy and electronic form and notifies them that the review is completed.

Step 6: Reflect on Process and Products

The final step in the RedLine process was specifically designed to incorporate the notion of Reuse Learning and to increase productivity by encouraging retention of reusable material. The step describes a reflective activity in which Jane is to:

- identify material she produced that should be saved for later use
- evaluate her use of RedLine relative to the process objectives she defined in Step 3
- suggest candidate RedLine process improvements or clarifications

Jane places into her personal process asset library the set of questions she compiled during her review and the measures of effort she collected about different types of reviewed material (pages of text, diagrams, tables, etc.).

Next, Jane evaluates her review against the first process objective (i.e., supporting conclusions with citations to relevant material). She finds this activity tedious because she embedded the citations in the text of each conclusion or recommendation and discovers that she missed entering some of them. She makes a note in her copy of RedLine to put citations at the end of each conclusion or recommendation in the future. She also notes that she should reuse this process objective the next time she uses RedLine.

Jane then evaluates her review against the second process objective (i.e., including at least one comment per major element of the plan). She concludes that the method she used for organizing the comments was effective (she used an outline of the FPD plan). She notes that she should reuse this method in the future and then places all her notes about this application of RedLine into her personal process asset library.

Jane's last action is to send a message to her organization's electronic mailbox for RedLine feedback. The message suggests that the use of an outline to organize the detailed review comments should be added to the process heuristics.

Commentary

In this scenario we have seen Jane following P-E-L idioms in her day-to-day work. That is, for Jane, reuse and learning have become a natural part of the way she carries out her responsibilities and improves her productivity. We have also seen how reuse and learning can fit into a general engineering practice, as evidenced by Jane's use of the RedLine process that has been institutionalized in her division.

In addition, we have seen Jane perform several analyses in evaluating the completeness and consistency of a reuse implementation plan, based on using the CFRP as a domain model of reuse processes. The analyses performed were to:

- compare the names of activities and processes to CFRP family and category names;

- compare the text descriptions of activities and processes to the descriptions of CFRP families and categories;
- compare the asset flows in and out of processes against the flows shown in the CFRP diagrams;
- classify the sequencing of activities and processes in terms of CFRP idioms, families, and categories.

Readers concerned with technology support issues should note that, except for the explicit use of electronic mail, no specific support technologies were identified in this scenario. The activities could have been highly automated or could have used paper and pencil. For example, Jane's personal process asset library could have been a bookshelf and a box of file cards, the indexing markers could have been "sticky notes", and the diagram could have been created by annotating a photocopy. On the other hand, CASE tools and an automated asset library mechanism would make Jane's job easier.

3.3 Scenario: Using the CFRP to Define an Application Engineering Process

Point of View

This scenario describes the activities of a process engineer responsible for developing a reuse-driven application engineering process.

Context

- **Setting**

  The Measurement Systems Applications (MSA) organization is the primary R&D group within Metrotek Corporation, a company that produces software applications that control and monitor diverse measurement instruments. MSA is organized principally by development program. Each program includes a set of projects that produce applications within a particular application area. Pat Mabutu manages the Radio Signal Analysis (RSA) program. Kim Lee manages the Communications Interception (CI) program.

  MSA also includes a number of groups that provide services to development programs and projects in the organization. These groups are managed centrally in a single department. They include Software Maintenance, Quality Assurance, and Process Improvement. Chris Mendoza is the senior process engineer for the Process Improvement group. Jan Swenson manages the Software Maintenance group.

  MSA has traditionally relied on software leverage (reusing substantial portions of previous applications, generally without prior planning) as well as other forms of ad hoc reuse in developing new applications. Metrotek management has asked MSA to move toward black-box reuse as a means of meeting business objectives for time-to-market and quality.

- **Goal**

  Chris has been given responsibility to define a reuse-based application engineering (AE) process via incremental changes to the existing MSA AE process, using the CFRP Definition document for guidance.

- **Assumptions**

  - The MSA organization is process-aware, with active Total Quality Management and Continuous Process Improvement programs in place.
  - MSA upper management is committed to moving from ad hoc software leverage towards establishment of centrally-managed asset bases to avoid maintenance redundancy. However, no significant changes have yet been made to implement this strategy.
  - MSA has a stable set of domains based on well-defined lines of business.
  - Chris has recently attended a one-day CFRP orientation presented to the Process Improvement group by an outside consultant. He thus has significant knowledge of CFRP concepts, but no practical experience in applying the CFRP.

Inputs

- The existing MSA AE process that defines, in abstract terms, the activities and interrelationships involved in application engineering within MSA.
- The existing MSA life cycle document that defines the life cycle that is followed in developing and evolving products within MSA. This document is consistent with the MSA AE process, but specializes it by imposing specific temporal sequencing, checkpoints, and milestones.
- Experience reports and lessons learned from projects that have applied the MSA life cycle document.
- Up-to-date copies of business objectives, strategy documents, and drafts of product plans for the RSA and CI programs.
- The MSA Process Modification Plan that defines how processes are evolved within the organization. The plan, based on the organization's Continuous Process Improvement approach, ensures that all affected parties are consulted throughout the modification effort, that impact on existing activities is analyzed, and so on.

Outputs

- The target MSA reuse-based AE process (with supporting documentation) that satisfies Chris's objectives and constraints.
- A document that describes how the existing MSA AE process will evolve toward the target MSA reuse-based AE process. The document, based on the Process Modification Plan, defines the objectives for each cycle of transition towards the new process and describes the sequence and timing for the introduction of process changes.
- A life cycle document describing the product life cycle for next generation projects within the RSA and CI programs, based on an expected transition to the MSA reuse-based AE process.

Scenario Activity

Chris's recent CFRP orientation has given him confidence that the correct approach in trying to incorporate reuse into the MSA AE process is to make it more consistent with the CFRP. To gain better insight into how this can best be achieved, Chris begins by reviewing the CFRP Definition and Application documents in detail. Chris decides to take a very methodical approach to applying the CFRP, and focuses initially on identifying the CFRP process elements that seem most appropriate to incorporate into the MSA AE process. He quickly determines that the Reuse Engineering idiom applies most directly to the task, although concepts from the Reuse Management idiom will influence the work as well.

After studying the Reuse Engineering idiom in detail, Chris decides that he will not try to define a complete set of Create-Manage-Utilize processes at this time. Chris knows, from reflecting on the implications of the CFRP, that Asset Management will have to be addressed explicitly at some

point as demands for asset support increase. However, he assumes for now that Asset Management will be performed by an existing MSA group, using mostly existing processes. Similarly, Asset Creation will have to be addressed when consumers identify asset needs that cannot be met with the existing asset base. However, investment in Asset Creation efforts will be difficult to justify at this early stage, and it is generally assumed that MSA's initial move to reuse will be based on reuse and/or reengineering of existing application artifacts. From this analysis, it is clear to Chris that his process modification effort should initially focus on incorporating CFRP Asset Utilization processes into the MSA AE process. Chris notes the risk of starting with Asset Utilization without explicitly addressing other reuse processes and their implications. He hopes that identifying such issues to MSA management will result in planning for the development of other reuse processes in the near future.

Looking at the Existing Organization and Infrastructure

Chris's next step is to assess the current MSA organization and its existing infrastructure to establish sufficient context for modifying the AE process. Chris draws upon his own knowledge of the MSA organization and conducts interviews to gain additional information that enables him to map the organization to the CFRP idioms and families. This process reinforces many of his initial conclusions. There is no formal Asset Creation group, although application engineering projects produce some artifacts that support limited reuse. The few CFRP Asset Management activities discernible within MSA are performed almost exclusively by the Maintenance group, and Chris learns that this group will be assigned general Asset Management responsibility, using the existing maintenance process. Chris identifies all of the application engineering projects as asset utilizers, but he notes that some processes in the Asset Utilization family, particularly Asset Tailoring, may be split between the AE projects and the Maintenance group (in its Asset Management role).

Because Chris's process modification task must deal with the real constraints of the MSA organization, Chris examines the existing infrastructure to assess how well it could, with little or no modification, support reuse-based processes. MSA's application projects already use a software development environment that includes a number of sophisticated development tools and strongly enforces configuration management policies. MSA has a strong training program, but it does not currently include any training that is explicitly reuse-oriented. The MSA engineering staff has no significant experience or expertise in managed reuse, but has a generally high level of technical competence. Overall, Chris sees some potential for adapting the infrastructure to support reuse, but decides to postpone recommending specific changes until he begins defining a plan for incremental adoption of the target MSA reuse-based AE process.

Pat, Kim, and Jan brief Chris on existing assets that might be placed in an asset library. Their conclusion is that the library will be initially populated with designs, code, tests, and usage documentation for about twenty large (1 KSLOC – 20 KSLOC), functionally-distinct components, and therefore should not be very complex. Chris adds the information on these assets to the data dictionary he has begun to develop for the MSA reuse-based AE process. Utilization of specific classes of assets will be explicitly addressed in the process, and terminology associated with those classes of assets will thus appear in the names of activities and data flows.

Chris notes that MSA has no existing reuse funding model and lacks appropriate incentives and rewards for managers and application engineers. The organization map Chris built earlier helps him identify the people who would need to sponsor changes in these policy areas. Chris concludes that MSA's director, T. J. Harris, must be educated about both funding and personnel issues.

Chris adds this to a list of issues that are external to the current process modeling effort but may eventually impact the overall MSA reuse program.

Comparing the Existing Process with the CFRP

Chris begins the development of the MSA reuse-based AE process by inspecting both the existing MSA AE process and the MSA life cycle document that is a concrete embodiment of the process. The ultimate target of Chris's work is a modified life cycle document that reflects his modified AE process, because that document will be the instrument that directly impacts the day-to-day work of application engineers in the future. During this activity, Chris consults the CFRP Definition document and highlights passages from the Asset Utilization section that are clearly relevant to evolving the current process.

Because the existing MSA AE process is organized as activities that each produce distinct kinds of life cycle products (e.g., requirements, designs, code, test cases, usage documentation), Chris quickly discerns that the CFRP Asset Utilization processes will play a role in each of the AE activities (e.g., analyze, design, implement, test). This will require a methodical approach to integrating the CFRP with the MSA AE process. Chris expects that the revised, reuse-based AE life cycle activities will be adopted at different times, reflecting phased adoption of the reuse of different life cycle products. However, he is not yet prepared to predict the exact order in which they will be adopted, so he decides to integrate the Asset Utilization processes with all the AE activities and defer definition of an incremental adoption strategy until later. Chris decides to approach the process integration problem by looking at each CFRP Asset Utilization process category and considering its role in each of the MSA AE activities.

Integrating CFRP Asset Criteria Determination

After reviewing the Asset Criteria Determination process category, Chris identifies the need for guidelines to help engineers define appropriate asset criteria and separate the criteria into the "shallow" criteria used in Asset Identification and the "deep" criteria used in Asset Selection. He decides that there should be a separate guideline document for each life cycle product, and each of these documents should be partitioned into guidelines for defining shallow and deep criteria. Chris authors an initial set of guideline documents, which include organization-independent, domain-independent examples of criteria, based on inputs from Pat and Kim's application projects. The guidelines initially include Asset Identification criteria examples such as "Code must be written in ANSI Standard C" and "Defect density in code must be less than 0.1 defect/KSLOC". Asset selection criteria examples include "Asset usage documentation must reflect the current state of the code" and "Design assets must specify interfaces consistent with the application architecture". Chris is careful to state in the guidelines that the included criteria are only examples, and actual criteria will be derived from characteristics of the asset base, the application requirements, and other factors. To make this point clear, he also authors a draft document that articulates an initial set of general principles for deriving shallow and deep criteria, based on context.

Integrating CFRP Asset Identification

MSA's existing AE process does not cover identification of existing software assets, but does define a method for requesting electronic copies of marketing and technical reports, planning documents, and measurement systems applications information. Chris extends this method to define a way of applying Asset Identification criteria to these information sources to find potential external assets

for use in an application engineering effort. In addition, Chris establishes a process for applying the Asset Identification criteria to the established in-house asset base to identify internal assets that are relevant to the application. Chris ensures that both of the techniques he has defined are applicable to all life cycle products.

Integrating CFRP Asset Selection

Considering the kind of asset library that Chris believes MSA is likely to establish (domain-specific and architecture-based, with large-grained, complementary assets), he initially sees no need for a sophisticated Asset Selection process. After consulting the CFRP Definition document, however, he recognizes that the Asset Selection activities focus on in-depth evaluation of identified assets and can be rather extensive. He also realizes that, since the Asset Identification process he has developed will identify assets external to the organization, the Asset Selection process must accommodate assets beyond the relatively limited scope of the internal asset library. Chris ultimately models the Asset Selection process to emphasize select/reject decisions based on in-depth analysis of assets addressing each of the MSA AE life cycle activities, driven by the Asset Selection criteria.

While modeling the process, Chris considers Asset Management and infrastructure issues associated with Asset Selection. In addition to an asset library mechanism, technology support for Asset Selection could include: tools for understanding requirements, design, and code; document processors and hypertext tools; and test harnesses and test suites. Chris also recognizes the importance of asset consultation services to guide users in the selection, and ultimately the reuse, of particular assets. Chris makes a note to address these issues in his incremental adoption plan.

As indicated in the CFRP Definition document, the MSA reuse-based AE process will need to address situations in which no asset fully satisfies the selection criteria. Chris asserts that the MSA reuse-based AE process should be an asset-centered process, in which engineers are encouraged to consider modifying their application requirements or designs when they aren't consistent with the asset base. However, he realizes that such an approach will be a major change in the application engineering process and will require a change in mindset that most engineers (and, for that matter, their managers) will find difficult to adopt. Chris meets with the management team to discuss this approach and draws analogies to the MSA hardware organization's practice of driving designs from preferred parts. The managers follow the analogy and approve Chris's proposal to prescribe an Asset Selection process that includes feedback to modify asset criteria, if appropriate, or to modify application system requirements or designs to use available assets. Chris captures this in the MSA reuse-based AE process, then composes a memo to the training organization describing requirements for a training package that could reduce engineer and project manager resistance to asset-centered application engineering. Chris has learned in a perusal of reuse literature that a policy of design inspections has been an effective mechanism to ensure applications are designed to reuse available assets, so this example is provided in the memo.

Integrating CFRP Asset Tailoring

One of the few serious constraints that has been imposed on Chris in defining the reuse-based AE process is the requirement that application engineers be prevented from controlling modifications to assets. This requirement, levied by MSA senior management, is intended to centralize asset modification responsibility within the Maintenance group. Chris recognizes that this management dictum strongly impacts the Asset Tailoring process. From the CFRP Definition document, Chris identifies two kinds of tailoring: (1) anticipated tailoring, in which the asset is designed to be

adaptable without the asset itself being modified (e.g., application generators, build-time adaptation via configuration parameters); and (2) unanticipated tailoring, in which the asset is likely to require modification (e.g., defect removal or function enhancement) to achieve the desired behavior. As with the other Asset Utilization processes already considered, Asset Tailoring can occur in each activity in the MSA application engineering process.

Chris schedules a meeting with Jan's Maintenance group and with one of the key senior managers to resolve whether or not Jan's group will control all unanticipated tailoring that requires internal modifications to assets. A compromise is reached that allows such tailoring to be performed by application engineers under some circumstances. Each needed modification will be reviewed, and those judged to have no persistent value outside the application for which the modification is needed will be performed by application engineers and not fed back to the asset base. All other modifications will be performed by the Maintenance group to evolve and enrich the asset base over time.

After further consideration, Chris sees that there are problems with this approach. The AE process must include analysis that identifies a need for asset modification, must include the request for modification, and must then include review and implementation of the requested modification. Chris is uncertain how to handle the situation in which Jan's organization can't review or implement a requested modification in time to avoid severely impacting an application's schedule. Who in the organization should decide about priorities in such matters? Chris notes that this kind of difficult issue needs to be resolved among the concerned parties themselves, who will be tasked with defining a clear protocol. The document defining that protocol will be maintained in conjunction with the MSA reuse-based AE process.

Integrating CFRP Asset Integration

Chris decides to request consultation from a senior technical designer, Sandy O'Grady, on Asset Integration issues. Chris specifically asks Sandy to author a document addressing Asset Integration in the context of the technology used in MSA, both currently and as projected over the next five years. Sandy looks at reusable document, design, and code assets and assesses them relative to the current and future environments in which their reuse is anticipated. The build tools for each type of asset are also studied. In some cases, no special integration requirements are identified, while others will require parameter setting, glue code, and encapsulation. Sandy writes the document and includes a number of examples for each likely kind of integration technique. Meanwhile, Chris makes sure that the AE process activities that receive assets as input provide for asset integration.

Ensuring Completion of Process Modification Planning Deliverables

Chris has now integrated CFRP Asset Utilization processes with the existing MSA AE process to produce a draft reuse-based AE process. Chris schedules a series of off-site meetings with Pat and Kim to evaluate and refine the proposed process and to produce a new life cycle document that reflects the process. They use the existing MSA life cycle document as one basis for guidance and comparison. The time spent developing the new life cycle document is a series of learning activities that gradually improve both the reuse-based AE process and the life cycle document.

During this period, Chris, Pat, and Kim jointly develop guidelines for incremental adoption of the new process, in accordance with the MSA Process Modification Plan. They agree that the life cycle document (rather than the more abstract AE process) should be the principal focal point

for recommending incremental changes that will lead toward the target process. In developing the guidelines, they realize that they need to address infrastructure evolution as well as process evolution. They address all the adoption issues that Chris noted while integrating the Asset Utilization processes with the AE process, and they identify some additional infrastructure evolution issues, as well. For example, they note that configuration management tools will need to have progressively more sophisticated capabilities and that mechanisms such as inspections and reviews may take on increasing formality to support the target process. After four off-site meetings, the threesome deliver the new life cycle document, *Radio Signal Analysis and Communications Interception Programs' Life Cycle for Next-Generation Projects in MSA*. Accompanying the document are a set of incremental adoption guidelines for managers and another set for engineers.

In reviewing the MSA reuse-based AE process he has developed, Chris is struck by the need for better coordination among activities. Asset Identification and Selection would both benefit from the expertise and lessons learned that could be provided by staff experts and former users and developers. Asset Tailoring requires coordination between asset utilizers and the Maintenance group when asset modification is needed, to be sure that the assets will still meet reusability requirements for future uses and that the changes are truly needed to accomplish the utilizers' needs. In light of these concerns, Chris recommends to Jan, Pat, and Kim that they form a reuse coordination steering committee consisting of (a) technical contributors who will assess what changes need to be made, and (b) managers who can prioritize changes and assign software engineering, technical writing, or test engineering staff to implement the changes. They then develop a plan to obtain T. J.'s support for changes that have strategic impact.

Commentary

MSA is an organization well suited to the process-driven reuse-based software engineering approach advocated by the CFRP. Their R&D organization already uses well-defined processes to plan and guide their application engineering efforts. Although there was little CFRP usage to draw on, Chris believed that the CFRP documents offered compelling arguments that an application engineering process such as the MSA AE process might be successfully modified to integrate CFRP Asset Utilization processes. He aggressively pursued such a strategy.

Chris approached the process modification project by carefully assessing each Asset Utilization process category and exploring how that activity would be integrated into the MSA AE process. A fundamental insight was that each of the AE process activities was subject to modification. In fact, every Asset Utilization process category is incorporated into each of the basic AE process activities. This results from the fact that each MSA AE activity produces a particular kind of life cycle work product and thus can reuse a corresponding kind of asset. The CFRP's Asset Utilization process categories are designed to apply to any kind of asset.

Chris addressed a number of organizational issues pragmatically in his planning task. For example, he deferred formal Asset Creation and Asset Management efforts until later, and he accommodated the fact that Jan's Maintenance group will be responsible for Asset Management and primarily responsible for Asset Tailoring. On the other hand, Chris prompted immediate substantial change by negotiating an agreement on a new asset-centered development policy. He also laid the groundwork for future changes by promoting learning in a number of ways, such as by establishing a reuse coordination steering committee.

3.4 Scenario: Using the CFRP to Plan an Asset Creation Project

Point of View

This scenario describes the activities of the planner of an Asset Creation project within a larger domain-specific reuse program.

Context

- **Setting**

  Kate, an Air Force Major, has been tasked to manage an Asset Creation project within a larger reuse program being undertaken by the Product Center of which she is a part. The Center has adopted the CFRP as an organizing framework for its reuse program and has provided CFRP orientation sessions for its program personnel. The Center has established a library in which to maintain the artifacts related to its Reuse Management activities (e.g., guidelines, plans, processes, history, lessons learned).

- **Goal**

  Kate's primary goal for the activity described in this scenario is to generate a CFRP-consistent plan for the creation of domain-specific assets for one of her product center's domains, with special emphasis on the initial domain analysis activity. Her secondary goal is to take a deliberately CFRP-consistent approach to her own planning activity by making her planning processes explicit, by utilizing existing processes and plans as the basis for her work, and by capturing her processes, products, and experience for reflection and potential reuse.

- **Assumptions**

  - The domain for the Asset Creation project has been selected by planning activities at the reuse program level.
  - The project is the second Asset Creation project to be planned within this reuse program.
  - The reuse program plan, organizational guidelines (policies, work product definitions, templates, etc.), and the management related products of other projects within this reuse program are in the Center's library.
  - The project planning effort involves defining:
    * specific project processes,
    * project interconnections,
    * project infrastructure requirements, and
    * resource requirements and allocations.

Inputs

The main inputs to Kate's planning activities are the plans created for the reuse program of which her project is a part, and organizational guidelines for her own activity and her work products. She also has as input the plans and results of Make Goods, the previous Asset Creation project in the program. A more detailed listing of her inputs follows:

- Reuse Program Plan
  - Objectives and strategies for the program
  - Scope of the program, including domain selections and definitions, with associated process and rationale documentation
  - Infrastructure plan
  - Program evaluation criteria
  - Identification of Asset Creation, Management, and Utilization projects and their relationships
- Requirements and templates for project planning work products and project library information
- Management work products from Make Goods
  - Plans
  - Process definitions
  - Project evaluation criteria
  - Evaluation results, lessons learned, and recommendations
- Existing infrastructure capabilities and associated results and lessons learned
  - For the program as a whole
  - For Make Goods

Outputs

The primary products that Kate will generate are a project plan and a definition of the processes that will be used on the project. Additional outputs include records of Kate's own processes and insights. In more detail, the outputs are:

- Project Plan
  - Objectives and evaluation criteria
  - Tasks
  - Infrastructure requirements
  - Resources
  - Schedule
  - Budget
- Process definitions for planned project tasks
- A record of Kate's reuse planning process, along with notes, insights, and lessons learned

Scenario Activity

Getting Started

Because she is committed to taking a CFRP-based approach to her work, Kate first obtains the STARS CFRP Definition and Application documents. She reviews, in particular, material in the CFRP Definition document related to the Reuse Planning family of the Reuse Management idiom and the Asset Creation family of the Reuse Engineering idiom. She also familiarizes herself with the content of the CFRP Application document, so that she knows where to look for specific information later.

Kate has been given a hardcopy of the plan generated for the reuse program of which this Asset Creation project is a part. This plan was prepared by her Branch Chief and the Center's Reuse Project Officer, who used the CFRP as an organizing framework for the plan. Kate reads the plan and discovers that it is quite high-level and gives the individual project planners a lot of discretion with regard to their planning approach and their interpretation and extension of the plan.

Because she and her organization are committed to moving towards a process-driven, reuse-based approach to all of their work, Kate next determines whether there are any defined processes for planning an Asset Creation project available in the Center's library. In this case there are none (the Make Goods planners did not document their planning processes), so she must rely on the CFRP documents for guidance. She decides to maintain a journal of her activities to capture the planning process for her own review and for possible reuse. She creates a project library (as an extension of the Center's library) in which to store this journal, her planning work products, and project history. She also locates electronic versions of the Center's reuse program plan (so that she can incorporate material from that plan into her own, as appropriate), and the plans and products of Make Goods.

Developing the Plan

In her planning process, Kate intends to undertake activities in each of the process categories in the Reuse Planning family (Assessment, Direction Setting, Scoping, Infrastructure Planning, and Project Planning). She decides to start her activity in each category by reviewing the decisions and guidance inherited from the reuse program, as described in the reuse program plan. Before proceeding with her planning, Kate re-reads the section of the CFRP Definition document that describes the process categories involved in Asset Creation (Domain Analysis and Modeling, Domain Architecture Development, and Asset Implementation) and reviews the IDEF_0 diagrams for that family in the CFRP Application document. She now feels prepared to start on her plan.

The high-level assessment contained in the program plan indicates significant expertise in the selected domain within the organization, but little knowledge of domain analysis and modeling techniques. A review of the recommendations and lessons generated by the learning activities associated with Make Goods indicates that an existing domain analysis method was tailored and applied, but that the products were not compatible with the object-oriented (OO) approach that the consumers preferred for software design. Kate notes that her project should benefit from both the in-house expertise in domain analysis developed on Make Goods and the other parts of the infrastructure that were used on that effort, but she takes special note of the need for compatible software design approaches across the producer-consumer communities.

Kate proceeds to set the direction and establish the objectives for this project (which she dubs Make More) by applying and specializing the Center's reuse program objectives to the project. She also looks at the Make Goods objectives, considers how well they were met, and notes the associated learning insights. As a result of this analysis and her earlier assessment activity, Kate adds the objective of making Asset Creation products compatible with the consumers' preferences. However, because of the uncertainty in this area, she modifies another project objective by reducing the target percentage of domain assets that will be reused by application projects within the next two years from 80% to 70%. As this last step indicates, Kate ensures that each objective is accompanied by metrics or success criteria to enable evaluation of whether or not the objective was achieved.

The program plan establishes the overall scope for the project (including the scope of the domain). To determine if any further constraints on the project's scope are appropriate at this time, Kate considers lessons learned about the scope of the Make Goods project. She notes that the participants in that project concluded that they had taken on too large a domain and that as a result there were insufficient resources to validate the products as planned. She decides that, rather than attempting to re-scope the Make More domain herself, she will require that the domain analysis task undertake its own scoping activity, and issues a guideline to choose depth over breadth. She includes the data reflecting the "size" of the Make Goods domain and the resources expended on that domain analysis as an appendix to her plan.

Kate reviews the reuse program's infrastructure plan, and also reviews the infrastructure that has already been implemented. She finds that the organization has obtained the documentation and training materials for the Domain Analysis Process Model (DAPM), the method that was used in Make Goods. She notes that the tailored version of DAPM used by Make Goods is also available. But she knows that method will not meet her objectives because the planned consumers of the products of Make More include the same object-oriented group that used the products of Make Goods. She reviews the overall experience with the method from the asset creators' perspective and finds that it is favorable, in particular because of its thorough documentation and a modularity that makes it readily modifiable. On this basis, she decides to spawn an effort to define a method that capitalizes on the domain analysis processes of the DAPM and yields products that are compatible with an object-oriented approach. She judges the successful development of such a method to be critical to achieving her objectives, so she directs that the task begin immediately and that it include a small pilot application. She temporarily suspends her own planning until she is confident that a workable method can be developed.

Refining the Domain Analysis Method

John, a Captain in Kate's Branch and a recent graduate of the Air Force Institute of Technology's Computer Science program, is chosen for this task because of his experience with object-oriented design and his enthusiasm for the move towards reuse-based software development. John was exposed to the CFRP in a one-day orientation sponsored by the reuse program, and he realizes that his task can be viewed as a Reuse Learning activity (specifically, an Innovation Exploration task) within the Make More Infrastructure Planning activity. In particular, John views this Innovation Exploration task as a distinct Plan-Enact-Learn loop embedded within Infrastructure Planning. He recognizes that his own planning activities will be influenced by planning decisions inherited from Kate's work and from the reuse program plan.

John starts his work by quickly reviewing the CFRP Reuse Planning processes. With regard to assessment, he notes that he lacks domain analysis experience and will need to spend some time

coming up to speed. In setting his direction, he realizes that his organization has made a substantial investment in the existing domain analysis method (DAPM) and the object-oriented application development methods that are in use, in terms of expertise, tools, documentation, and training. He thus establishes an objective to retain as much of these existing methods as possible to take maximum advantage of the established investment. In scoping the effort, John decides that the pilot project will focus on a small subset of the Make Goods domain because the project should be able to leverage the existing Make Goods DAPM products to quickly assess the new method. Infrastructure planning for John's task involves verifying that the documentation and training materials for DAPM, the DAPM support tools used by Make Goods, and the latest version of the OO design tool favored by the organization are available. In planning resources and schedules for this effort, he estimates that he will work half time for about eight weeks and, for the four-week pilot project, will require the half-time support of Lee, a Second Lieutenant who worked on Make Goods.

John gets into action by first reviewing several other domain analysis methods (in this case, Feature Oriented Domain Analysis, Organization Domain Modeling, and JIAWG Object-Oriented Domain Analysis, all referenced in Appendix B of the CFRP Application document) to get some broad understanding of the topic. He then studies the DAPM documentation and training material, the Make Goods tailoring of the DAPM process, and the domain products that Make Goods generated.

After some consideration of the relevant issues, and several discussions with the developer of DAPM, John decides that a hybrid DAPM/OO method is feasible and proceeds to develop such a method. The hybrid method uses the DAPM techniques of vocabulary analysis, conceptual clustering, and faceted classification for identifying objects and for deriving a conceptual domain model, while object-oriented analysis (OOA) and object-oriented design (OOD) techniques and notation are used to formalize and document a domain architecture and component specifications.

After John defines and documents the new method, named Domain Analysis For Object Oriented Development (DAFOOD), John and Lee undertake the pilot application, which involves redoing the Make Goods work in the small subdomain John identified earlier. They apply DAFOOD as documented and generate OO-compatible products, but experience some uncertainty in the transformation of the DAPM products into OOA concepts and notation.

Their commitment to a CFRP-based approach to their work prompts John and Lee to take a look at the Learning processes before declaring themselves done. They engage in some observation and evaluation of their small project to see what can be learned. They analyze the DAFOOD method by determining the percentage of DAPM and OO activities that were incorporated into DAFOOD and counting the number of changes that were made to those activities during DAFOOD development. Based on this analysis, they decide that they have achieved their objective of minimizing changes to existing methods.

However, as they analyze the effectiveness of the DAFOOD method in their pilot application, they become concerned that their approach to integrating the existing methods may have led to difficulties in transitioning between the DAPM and OO aspects of DAFOOD. They decide to review the notes they took during the pilot and carefully analyze the steps in which the problems occurred. They agree that one of the DAPM products is not completely specified, and the ill-defined process of mapping that product to the OO notation leaves much to the discretion and imagination of the person doing the analysis. To address these problems, John proposes several enhancements to the DAPM product specification and introduces two new explicit DAPM-to-OO transition steps into

the method. Lee tries these changes and concludes that the transition now goes more smoothly. They generate a recommendation that the modified version of DAFOOD be used on Make More, and suggest that careful attention be paid to the new steps because they were not fully validated in the pilot.

Developing the Plan (Resumed)

Having participated in some of the Learning sessions with John and Lee, Kate is convinced that they have a viable new domain analysis method. She recognizes that the DAFOOD method includes architecture development as well. In discussions with John, she learns that it is premature to commit to a particular approach to Asset Implementation because that determination will best be made towards the end of the DAFOOD process. Thus Kate determines that her Asset Creation planning activity at this time encompasses a combination of Domain Analysis and Modeling and Domain Architecture Development processes. Since she has already seen the benefit of Learning activities, she decides to include explicit Reuse Learning tasks in her plan as well.

Kate reviews the technical infrastructure requirements for the DAFOOD process and determines whether the needed platforms and tools are available. In this case one complete suite is in house and available, but a second suite is required. These additional infrastructure needs are reflected in the financial, tasking, and scheduling sections of the emerging project plan.

Kate next reviews the organizational and educational infrastructure to support the DAFOOD process and associated technology. She notes that the organizational structure, policies, procedures, incentives, etc., that have been established by the overall organization and by the reuse program seem generally sufficient to staff the project and provide general support. Kate finds that vendor courses are available for the selected tools and that the training material as modified for Make Goods is also available. However, the training material will need to be modified further to reflect the changes that resulted in the DAFOOD method. Again, this need is reflected in the financial, tasking, and scheduling sections of the plan.

Kate can now solidify the project resource requirements and make specific recommendations. Based on review of the documentation of the selected process (DAFOOD) and the staffing of Make Goods, Kate defines the detailed staffing requirements for the project, in terms of job categories and skills as well as numbers. She reviews the domain selection report generated by the reuse program planning effort to identify domain experts. She identifies in the plan the individuals whom she believes are best qualified to perform the DAFOOD processes, and identifies their organizational position and relationships. She then establishes a recommended budget and spend plan for the project, broken down into monthly intervals.

Finalizing the Plan

Kate completes the proposed project plan in accordance with guidelines and templates established by her organization. She distributes this material to planned staff members, higher-level managers, identified domain experts, and selected personnel from Make Goods for their review. She negotiates and modifies the plan in response to feedback from the reviewers and then submits the plan for approval.

Recording History and Lessons

While she waits for approval Kate reviews the content of the project library thus far to ensure that all work products are present and current. She also reviews and completes the project history to date. She finally completes and reviews her journal of the process followed in this planning activity.

Commentary

In this scenario we have seen Kate using the CFRP both to guide her own planning activities and to shape her plan for the Make More project. She performed each of the process categories of the Reuse Planning family. When she began the Infrastructure Planning process and reviewed some lessons from the Make Goods project, she realized that she needed to ensure that there was a viable domain analysis method before committing to a Make More effort.

Kate then initiated an Innovation Exploration process to combine two existing technologies to form a new domain analysis method. In that task, John and Lee stepped through a Plan-Enact-Learn loop to develop the DAFOOD method and assess it through application in a pilot project. They then cycled through the loop a second time to evolve the method to address problems identified during the pilot.

Kate based the tasks in her plan on both the Asset Creation and Reuse Learning process categories. With regard to Asset Creation, she mapped the Domain Analysis and Modeling and Domain Architecture Development categories to a single task, and postponed any planning of Asset Implementation.

3.5 Scenario: Using the CFRP to Plan a Reuse Program

Point of View

This scenario describes the activities of a technical planner beginning the Reuse Planning process for an entire reuse program. This includes the high-level planning of Asset Creation, Management, and Utilization projects within the scope of the overall program.

Context

- **Setting**

  The Veteran's Administration (VA) has issued an RFP for a next-generation, integrated multimedia-based hospital information system, called the VA Medical Open-Architecture System (VAMOS). The system is to be deployed nationally within the VA hospital system over a ten-year period. The RFP requires that proposals include a Reuse Program Plan (RPP) that addresses the full VAMOS deployment cycle and demonstrates technical and methodological competence in reuse.

  MediSoft Corporation, a mid-size firm specializing in real-time medical software engineering applications, intends to submit a proposal for the VAMOS contract and has prepared an initial draft of the proposal. Jack is a MediSoft software program manager, with a background in real-time medical software engineering applications, who has become known as a reuse advocate within the company. He is tasked with reviewing the draft proposal to assess its responsiveness to reuse issues, and to make specific recommendations for the RPP that will be integrated into the proposal. Jack has recently attended an orientation on the CFRP, and decides to use this task as an opportunity to apply the CFRP in the planning process.

- **Goal**

  Jack must produce a review of relevant aspects of the draft proposal, develop a set of recommendations for the RPP, and show the impact of his recommendations on the current proposal strategy. He will first present his review and recommendations to the proposal team, then to MediSoft's software division manager, who has final say on the overall proposal effort. Technical managers must be convinced that his plan offers a coherent approach to risk reduction, reuse adoption, and technology transfer issues. Jack also wants the presentation to incorporate CFRP concepts and terminology in a way that will communicate effectively to the proposal team and to the VA's proposal evaluators.

- **Assumptions**

  - In current VA software practice, a large, standardized MIS system is in use throughout the national VA hospital network. Each major module of this standardized system is maintained by a different regional VA programming center. This approach has served to minimize configuration management complexity for the VA, and has worked well in the MIS context.
  - MediSoft Corporation has a culture of informal, ad hoc reuse. The corporation has recently established an objective to transition to a more domain-specific reuse-based approach to software engineering. However, no systematic or managed internal reuse program has yet been established.

  - Neither the MediSoft proposal team nor the VA's proposal evaluators have significant knowledge of the CFRP.

Inputs

- Relevant sections of the RFP calling for the Reuse Program Plan (RPP)
- The current draft MediSoft proposal

Outputs

- A list of review comments on the current draft proposal
- The RPP recommendations, in outline form

Scenario Activity

Setting the Context

Jack begins by reading the VAMOS RFP and re-reading the CFRP Definition document, then reading the draft MediSoft proposal. He chooses this sequence in order to reflect upon the RFP from a CFRP perspective, before being too influenced by the approach in the draft proposal.

VAMOS RFP Review: The VAMOS RFP specifies certain reusability issues the RPP must address, including:

- adaptability to multiple hospital environments
- a domain architecture allowing incorporation of new medical and communications technology as it becomes available
- planning for possible scaling and adaptation to other VA application areas

Jack wonders whether these points constitute a complete list of the reuse issues deemed relevant to the VA, or are intended only as examples that reflect a more comprehensive set of reuse objectives. He decides to assume the latter in his planning, and concludes that the VA customer will respond positively to an innovative technical approach to reuse in the VAMOS proposal. However, Jack makes a note to verify these key points with the proposal team.

CFRP Review: Reflecting on his recent CFRP orientation, Jack asks how the VAMOS program fits within the CFRP framework. He determines that the reuse program called out in the VAMOS RFP corresponds quite closely to a CFRP "reuse program" (specifically, a Plan–Enact–Learn process cycle encompassing one or more Reuse Engineering projects). Jack expects that there may be several Asset Creation projects within the reuse program, each corresponding to an entire domain engineering effort to be initiated within the VAMOS program. Similarly, he sees that efforts to

develop and maintain major VAMOS modules and perform overall VAMOS system integration could be defined as separate Asset Utilization projects. He does not see a clear analogue to an Asset Management project in the RFP, so he makes a note to review the draft proposal regarding this issue and address it in his own RPP recommendations.

Jack's CFRP orientation emphasized that a reuse program may consist of a sequence of iterations or "reuse cycles" (as described in the Reuse Management section of the CFRP Definition document). Jack reviews the VAMOS RFP and considers the impact of partitioning the program into multiple phases, structured in terms of CFRP reuse cycles. Jack decides to review the MediSoft proposal before pursuing these ideas further.

Draft MediSoft Proposal: The draft MediSoft proposal is based on development of a standard generic architecture that will be deployed at each VAMOS site along with some mandated standards and components. Custom applications based on these standard capabilities will be written to satisfy the unique needs of each hospital environment. Jack recognizes that this approach is modeled on the current software practice for managing the VA's nationwide MIS system (as described in Assumptions, above).

Although this approach is consistent with current VA practice, Jack believes it will prove inadequate for the complex and rapidly changing application area of real-time patient monitoring and data analysis software. Based on his applications knowledge, Jack believes a more flexible architecture framework is needed to address commonality and variability across the range of intended VAMOS installations. Such flexibility will be even more critical when addressing the need to adapt VAMOS capabilities to other VA application areas, as stated in the RFP. Jack notes that this technical approach reflects the concept of domain-specific, architecture-based reuse advocated in the CFRP. He also realizes (with some concern) that such an approach will significantly impact both the development plan and architecture for the system in the current proposal. He summarizes these comments for his presentation.

Determining the Planning Approach

Jack now has a CFRP context for his planning activity and an initial sense of the technical approach he will advocate for the RPP. Before he can begin detailed work on the RPP, Jack feels he needs to establish an overall planning approach. He looks for a well-defined reuse planning process he can follow, or at least a good example of a reuse program plan to give him guidance, but finds nothing aside from the CFRP itself.

Jack thus reviews the CFRP Reuse Planning process categories to gain some insight into how to proceed. He realizes that he has already performed some degree of Assessment and decides that he will continue to weave Assessment activities throughout his planning process as he uncovers new aspects of the VAMOS situation requiring reflection and evaluation. Jack notes that the overall direction and scope of the program are defined in the RFP and refined in the MediSoft proposal, so he decides not to pursue Direction Setting and Scoping as distinct major activities within his planning process. He acknowledges, however, that he may further refine the direction and scope while performing other planning activities, and he realizes that he has already broadened the technical scope by electing to propose a more ambitious architectural approach. Jack wonders, given the high-level nature of the RPP, if there will be a need to plan the reuse infrastructure in any detail. He decides that he will not perform Infrastructure Planning as a discrete planning step at this stage in his task, but will address infrastructure issues appropriately as they arise.

In the end, Jack concludes that the main thrust of his planning task will be the CFRP Project Planning activity, with other planning activities interleaved appropriately. He decides that the major objectives of this activity will be to define a set of overall program phases, define candidate reuse projects and the kinds of interactions that will take place among them, and address issues associated with the incremental adoption of the reuse approach within the program.

Jack next considers the general level of technical detail and overall planning emphasis that should be reflected in the VAMOS RPP. The RPP must address the entire ten-year system acquisition and roll-out period, and Jack decides that it will be impossible at this time to anticipate the technical issues that will arise throughout this period. He thus concludes that it is inappropriate to plan the Reuse Engineering approach in detail and decides that the RPP should not discuss Reuse Engineering processes below the CFRP family level (i.e., Asset Creation, Management, and Utilization). However, he believes he can lay out a relatively detailed, phased planning and management approach that will be applicable across the ten-year period, so he decides that he will try to incorporate Reuse Planning, Enactment, and Learning processes into the RPP at the CFRP category level as much as possible.

Jack remembers from his CFRP orientation that the Reuse Management processes must be tailored to and integrated with the organization's overall program and project management processes. To gain additional insight into the overall MediSoft processes as they are applied in the VA context, he contacts the program manager for an earlier MIS-based hospital system developed by MediSoft for the VA. Jack talks with the program manager about how initial planning was done and what lessons were learned. Jack concludes that many aspects of the earlier management process will be applicable to the VAMOS program, and he writes down a number of ideas about how to integrate those aspects with the CFRP Reuse Management processes. The program manager agrees to review the RPP when it is completed.

Defining the Program Phases

Jack is now prepared to begin defining the plan. In thinking about how the overall program should be structured, he revisits the notion of multiple program phases based on CFRP reuse cycles, which he had considered when reviewing the CFRP earlier. To improve his understanding of these concepts, Jack re-reads the portion of the Reuse Management section in the CFRP Definition document that discusses reuse programs, cycles, and initiatives. Based on the knowledge he has gained about the RFP and the draft proposal, he decides to recommend an approach with three major phases, as follows:

- A first cycle (the "reuse initiative") to explore technical alternatives, develop prototype VAMOS assets, and verify them by constructing VAMOS system prototypes using the assets.
- A second cycle encompassing development of "production-quality" assets and reuse-based development and deployment of one full VAMOS system.
- Subsequent cycles that address system adaptation by regional centers, as well as maintenance and enhancement of the assets and systems.

In this cyclic context, lessons learned and recommendations for improvement flow from the learning activities of each cycle to the planning activities for the following cycle. Jack prepares an illustration depicting this phased approach that he will include in his presentation to the proposal team.

Planning the Program Cycles

As Jack begins to consider how to structure the activities within the program cycles, he again reviews the Reuse Management section of the CFRP Definition document. As he is reading, he gradually realizes that much of the detail he had expected to incorporate into his plan at this time will have to be deferred to planning activities within the individual program phases because he lacks sufficient context at his level of planning. In thinking about these issues, Jack suddenly understands something that he was only vaguely aware of before: his focus on "planning the planning" processes for the RPP is an example of the concept of "recursion" in the Reuse Management idiom, as described in Appendix A of the CFRP Definition document. He re-reads Appendix A to verify this interpretation and further clarify his understanding of it. The concept of CFRP recursion had seemed quite abstract to Jack during the CFRP orientation, and he is intrigued to find it applicable to his own planning task. He decides to describe his discovery of a practical example of CFRP recursion as a lesson learned for the CFRP developers.

Jack proceeds to "plan the planning" by first allocating a number of overall program planning activities to the Reuse Planning processes within the initial program cycle (the "reuse initiative"). He then fleshes out the cycle by elaborating on all the processes within the overall Plan–Enact–Learn loop. He describes these processes in as much detail as he can given his limited perspective, and also places them in the context of the overall MediSoft program management processes, based on what he learned about those processes earlier. He structures the other program phases similarly, though somewhat differently to reflect the distinct roles each of the phases will play within the overall program.

Jack recognizes that the proposed CFRP-based approach to reuse will be unfamiliar to the VA developer and user organizations and to contractor organizations such as MediSoft. A transition to this approach will require substantial technological and cultural change within those organizations. An overall strategy must be defined for incremental adoption of key reuse concepts and technology by the VAMOS stakeholder organizations throughout the life of the program, with a particular emphasis on the initial program cycle. Jack consults Appendix B of the CFRP Application document for help in this area and sees that the STARS Reuse Strategy Model and the VCOE Reuse Adoption Guidebook may offer assistance in developing a reuse adoption strategy. After obtaining and reviewing these documents, Jack outlines a high-level transition plan involving systematic assessment and evolution of reuse capabilities within each VAMOS stakeholder organization. The plan also includes activities to coordinate reuse adoption across the stakeholders. In addition, it includes global VAMOS efforts to establish key technical capabilities central to the entire program and ensure broad acceptance of those capabilities among all stakeholders.

One implication of this transition plan is that the Assessment activity within the initial program cycle will be very extensive. It will involve thorough assessment of the current state of reuse practice within the stakeholder organizations, and it will incorporate a preliminary Reuse Learning phase in which studies and experiments are performed to identify potentially applicable processes, methods, and tools for initial use on the program. The results of this expanded Assessment activity will then provide sufficient context for the initial Scoping and Infrastructure Planning activities.

Planning Reuse Projects

As a critical component of his reuse transition plan, Jack proposes a set of pilot reuse projects in the initial program cycle as part of the overall prototyping and feasibility phase for VAMOS. The pilots

will demonstrate the feasibility of domain-specific, architecture-driven reuse within the VAMOS application area. Their success will result in buy-in from VA and MediSoft upper management, product line managers who will need to contribute staff and resources, and engineers who will work on the program and who must be willing to use the assets developed.

Specifically, Jack sees two critical areas of technical risk for reuse in the VAMOS application area, and proposes two related domain engineering pilot projects to address these areas. The first project will focus on developing a prototype architecture for the overall VAMOS system by performing a domain analysis on a selected set of similar architectures from existing medical imaging systems in the commercial sector. This project will serve as a proof of concept for the viability of the more flexible architectural approach Jack has proposed. The second domain engineering project will focus on building reusable components in a narrowly scoped domain. This project will serve as proof of concept for the viability of achieving reuse in domains with tight real-time constraints, rapidly changing technology, and numerous hardware platform and peripheral dependencies. After consulting with personnel from various product lines, Jack suggests ultrasound data management as a possible domain for the second project.

Jack also proposes two application engineering pilot projects that correspond directly to the domain engineering pilots. These projects will assess and apply the prototype architecture and component assets, both to validate them and to provide feedback to improve the assets and the processes and methods that are used to create them.

Next, Jack tries to develop a general VAMOS deployment strategy in terms of CFRP Asset Creation, Management, and Utilization projects. He envisions a number of domain engineering projects, including outgrowths of his initial pilot projects and additional projects addressing domains to be selected early in the second program phase. Jack recalls that both the VAMOS RFP and the draft proposal had not adequately addressed the role of Asset Management. Jack proposes for the RPP that, depending on the types of reusable assets created, one or more VAMOS "reuse technology centers" be established, each responsible for a different component domain and an associated Asset Management project. He decides to emphasize to the proposal team that these centers could be viewed as a refinement of the current VA partitioning into regional programming centers. In this view, each center would manage, not a module of a standard system, but a domain-specific asset base utilized by the various sites where instances of the operational VAMOS system are installed. The integration, customization, and installation of these operational systems at VAMOS sites would constitute Asset Utilization projects. To support these projects, Jack proposes that tools be developed to customize and tailor VAMOS assets for incorporation into operational systems.

Planning Reuse Project Interactions

As the final step in developing the RPP, Jack feels he needs a better understanding of the interactions among the various Asset Creation, Management, and Utilization projects he has delineated. He realizes that this interaction will be quite different from the current organizational structure. Jack decides to model all the stakeholders in the VAMOS context that might create or utilize reusable assets, even if his reuse approach were not adopted. To his surprise, Jack finds a number of "layers" of potential creators and utilizers, including:

1. Prime contractors, who will create the overall domain architecture
2. Current regional software centers, who will adapt modules in the VA's existing MIS system

to interface with VAMOS, and may take over maintenance responsibility for some part of VAMOS as well

3. Third-party commercial software developers of niche applications to be integrated into the overall VAMOS architecture
4. System integrators and technical support personnel associated with each hospital
5. Medical specialists and database administrators, who may create and access "medical information assets" (codified medical knowledge particular to various hospital specialty centers) over the VAMOS network
6. System operators and technicians, who will need to program routine procedures into the system

When the various domain engineering projects and technology centers in his proposed RPP are added to this already rich set of stakeholders, Jack realizes that the program will involve many asset producer–consumer relationships, along with more conventional project interactions. He modifies his VAMOS deployment strategy in some ways to address these issues, but he realizes that a more in-depth analysis will be needed in the initial program cycle to fully flesh out the strategy. In considering ways to perform this analysis, Jack recalls the CFRP notion of "cascading" markets, where engineers may utilize assets in one reuse context in order to create different kinds of assets in another reuse context. He re-reads Appendix A of the CFRP Definition document, where the CFRP concept of cascading is described. He believes that this notion is quite applicable to the VAMOS program, and could lead to new kinds of reusable components through identification of producer–consumer relationships that otherwise would not be discovered.

Jack decides to recommend that the Assessment task within the initial program cycle be closely coordinated with the task of gathering system and site requirements for the VAMOS system from each of the stakeholder organizations. The reuse assessment team will document a more complete VAMOS stakeholder model in CFRP terms and will interview selected personnel from each organization to identify reuse capability levels, potential reusable artifacts and processes, and potential producer–consumer roles.

Finalizing and Presenting Recommendations

As Jack reflects on his experience in applying the CFRP, he notes that the CFRP perspective has helped him discover at least two potential weaknesses in the current proposal's technical approach: a reliance on an over-simplified architecture that will not adequately accommodate the complexity of the VAMOS domain, and no recognition of the need for a planned Asset Management approach. He also notes that he has discovered some innovative opportunities that might otherwise have been missed, such as the insight that VAMOS system end-users might potentially act as asset creators for medical information assets. Jack believes his reuse plan defines a sound phased approach for managing the overall program and individual reuse projects. The plan also offers a realistic reuse transition path for the VA environment that adequately manages risks and could gain the acceptance of the MediSoft team — quite possibly even win the contract.

Jack prepares a set of viewgraphs that summarize his review of the draft proposal, his interpretation of the technical challenges, risks, and opportunities within the RFP, and his proposal for the RPP. He presents the material to the proposal team and receives feedback. Most find the overall

approach compelling and innovative. Some concerns are raised about the difficulty of adequately communicating the concepts in the proposal, and concern is also expressed about the impact of major changes on the current proposal schedule. Jack incorporates the feedback into his presentation to the division head, who is persuaded to accept Jack's key recommendations and instructs his marketing manager to begin raising the VA customer's awareness of CFRP concepts immediately. The division head also decides that all proposal teams should attend an initial CFRP orientation in the future.

Commentary

This scenario shows Jack using high-level CFRP concepts as a basis for reviewing a draft proposal and defining a new reuse program plan. In his planning process, he directly used the concepts of a reuse program; reuse cycles; a reuse initiative phase; reuse engineering projects: Asset Creation, Management, and Utilization process families; domain-specific architecture-driven reuse; and the Reuse Planning process categories. He also incorporated these concepts into his plan.

Jack took steps to integrate reuse planning elements with MediSoft's overall program management practices in the VA context. Jack also discovered that CFRP-based reuse processes are scalable and applicable at more than one level of planning. Because of the complexity of his planning task, Jack stumbled on the need to define lower-level planning processes using the technique of CFRP recursion. He also found a useful application of the notion of cascading asset creator, manager, and utilizer markets.

Jack recognized the need for a planned approach to reuse adoption within the VAMOS program. With the help of two documents listed in Appendix B, he developed a high-level reuse transition plan addressing the overall program and the individual VAMOS stakeholder organizations. The plan proposed a set of pilot projects that not only address key technical issues, but also promote buy-in to the reuse approach among the VAMOS stakeholders.

3.6 Scenario Review

The scenarios are designed to provide concrete examples of applying the CFRP and to communicate the central themes associated with the CFRP (presented earlier in Table 1). This section reviews and analyzes the scenarios, primarily in terms of how they communicate the CFRP themes.

The themes are reflected both in the activities performed by the individuals in the scenarios and in the work products that they generate. A mapping of the themes to the scenarios is shown concisely in Table 2. In the table entries, "H" implies that there is a high correlation between a theme and a scenario, "L" implies that there is low but significant correlation, and an empty entry implies that there is no significant correlation. The first five of the themes listed in the table are the major themes in this document, because they are evident across all of the scenarios. The other themes are less pervasive.

A more detailed discussion of how each theme is addressed by the scenarios is included below:

- **1. A reuse-based approach to software engineering should be driven by well-defined, repeatable processes.**

  A central aspect of scenario 1 is the process-driven RedLine approach to the Reuse Management task of reviewing a reuse plan. The major activity in scenario 2 is the integration of the CFRP Asset Utilization processes into the existing application engineering process, enabling process-driven reuse within the MSA organization. Scenario 3 features the definition of a domain analysis process for the Make More project. Scenario 4 shows that the process-driven aspects of reuse extend to high levels, as Jack plans the management of the VAMOS program from a process perspective.

- **2. Software reuse has both management and engineering dimensions, whose activities are captured in the CFRP idioms.**

  In scenario 1, Jane uses both the Reuse Management and Reuse Engineering idioms to structure her view of the reuse plan's functions and relationships. In scenario 2, Chris uses the Reuse Engineering idiom as a basis for understanding existing MSA reuse practices and determining which aspects of reuse should be emphasized in the near term. In scenario 3, Kate and John both "live" the CFRP Reuse Management idiom by consciously engaging in P-E-L processes, and Kate applies the Reuse Engineering idiom concepts in her planning activity. In scenario 4, Jack directly incorporates the Reuse Management idiom into his proposed plan and also carefully considers the implications of family interrelationships within the Reuse Engineering idiom.

- **3. CFRP process categories provide a definition of the activities involved in a process-driven, domain-specific reuse-based approach to software engineering.**

  In scenario 1, Jane assesses the reuse plan by mapping it to the CFRP categories (as well as the idioms and families); as a result, she identifies the missing Domain Analysis function. In scenario 2, Chris integrates each of the Asset Utilization process categories into the MSA application engineering processes. In scenario 3, Kate and John are guided by Reuse Planning and Learning categories in defining their own processes, and Kate relies on the Asset Creation categories to tell her what tasks might need to be planned and how they are related. In scenario 4, Jack uses the Reuse Planning categories to characterize and guide his own planning

	CFRP Themes	Scenario 1	2	3	4
1.	A reuse-based approach to software engineering should be driven by well-defined, repeatable processes.	H	H	H	L
2.	Software reuse has both management and engineering dimensions, whose activities are captured in the CFRP idioms.	H	L	H	H
3.	CFRP process categories provide a definition of the activities involved in a process-driven, domain-specific reuse-based approach to software engineering.	H	H	H	L
4.	Reuse should be applied as a "first principle"; that is, reusable products should always be considered as the basis for work before creating new products; experiences, processes, and workproducts should always be recorded for learning and for possible reuse.	H	H	H	L
5.	Measurement, learning and managed change are essential and pervasive in reuse.	H	H	H	H
6.	Infrastructure is important to reuse and must be designed to support it.		H	H	L
7.	A domain-specific, architecture-driven approach to reuse is important, from both an engineering and a management perspective.	H		H	L
8.	The asset producer, broker, and consumer roles are distinct within Reuse Engineering.	L	L	L	H
9.	The CFRP is generic with respect to domains, technologies, management styles, and economic sectors.	H	H	H	H
10.	CFRP processes should be integrated with overall planning and engineering practices.	H	H		L
11.	The CFRP is a process modeling language with mechanisms to support composition of complex process configurations.			L	H
12.	The CFRP is scalable and applicable at different organizational levels.	L		L	L
13.	The CFRP is a domain model and high level process architecture for the reuse process domain; it provides a basis for the analysis of reuse processes and the definition of reusable process assets.	H		L	

Table 2: Mapping Between CFRP Themes and Scenarios

and integrates the Reuse Management categories into the planning processes to be performed within the proposed reuse program.

- **4. Reuse should be applied as a first principle.**

  Jane in scenario 1 and Kate in scenario 3 use a library of reusable assets and contribute their work to a library. Jane also reuses a reusable process, RedLine. In scenario 2, Chris emphasizes an asset-centered development process, in which the assets available for reuse can influence application requirements. Chris also considers measures to encourage adoption of this approach among the engineering staff. John in scenario 3 reuses and adapts an existing domain analysis process model. John in scenario 3 and Jack in scenario 4 reuse the experience of other individuals in their organizations.

- **5. Measurement, learning, and managed change are essential and pervasive in reuse.**

  In scenario 1, Jane records and reflects on her experiences and adds material to her own library of reusable material. Her learning activity also provides a guideline to enhance the reusable RedLine process. In scenario 2, Chris emphasizes the need for incremental evolution and adoption of the reuse-based application engineering process model, and he also addresses

issues concerning the long-term transition towards a more comprehensive approach to reuse within the overall MSA organization. Kate in scenario 3 takes good advantage of the lessons learned by the previous Asset Creation project's learning activity and avoids another mismatch between the products created and the products needed by the users. Also in scenario 3, John and Chris measure their changes to the existing methods and evaluate their work against their objectives. In scenario 4, Jack plans initial learning activities that will be needed as the reuse program gets started, and he develops a transition plan to facilitate reuse adoption within VAMOS stakeholder organizations. Jack also reflects on what he has learned from using the CFRP itself.

- **6. Infrastructure is important to reuse and must be designed to support it.**

  In scenario 2, Chris incorporates reuse processes into an existing element of the infrastructure, the application engineering process. Chris also reviews other aspects of the existing infrastructure (e.g., tools, policies, funding models, incentives) and subsequently considers infrastructure requirements to support the reuse-based application engineering process being defined (e.g., asset consultation, program understanding tools, test harnesses, training). In scenario 3, a significant part of the activity involves revising an element of the existing infrastructure, the domain analysis process. Planning for tools to support the process is also performed. In scenario 4, Jack considers changes in educational and organizational infrastructure that will be needed to support a transition to his proposed reuse approach.

- **7. A domain-specific, architecture-driven approach to reuse is important, from both an engineering and a management perspective.**

  In scenario 1, Jane notes the use of a generic architecture to develop the prototype reuse plan and suggests that it also be used in the analysis of user requirements. In scenario 3, the purpose of the project being planned is to generate a domain-specific model and architecture. In scenario 4, Jack proposes a pilot project to focus on the VAMOS domain-specific architecture because he believes that a more flexible architecture than the current one is needed.

- **8. The asset producer, broker, and consumer roles are distinct within Reuse Engineering.**

  Jane in scenario 1 maps the activities in the FPD plan to the Reuse Engineering families to clarify the roles identified in the plan. In scenario 2, Chris considers the distinct Reuse Engineering roles in mapping the existing MSA organization to the CFRP and delineating the scope of the application engineering process being defined. In scenario 3, Kate is addressing the producer role but is mindful in particular of the consumers when she initiates a revision of the domain analysis process to better meet their needs. In scenario 4, Jack explicitly looks at the many stakeholders in the VAMOS environment, identifies them as creators, managers, or utilizers, and considers the numerous potential interrelationships among them.

- **9. The CFRP is generic with respect to domains, technologies, management styles, and economic sectors.**

  This theme is illustrated not by any single scenario but rather by the collection as a whole. Scenarios 1 and 2 address the private sector, scenario 3 addresses the government sector, and scenario 4 touches on both. The scenarios address entirely different domains, occur in different organizational contexts, and assume different types and degrees of technology support.

- **10. CFRP processes should be integrated with overall planning and engineering practices.**

  In scenario 1, Jane follows the RedLine process, which has incorporated the Planning, Enactment, and Learning processes of the Reuse Management idiom into a general document review process. The central focus of scenario 2 is to tightly integrate Asset Utilization processes into each of the existing application engineering process activities. In scenario 4, Jack's task is to infuse a reuse plan into the overall life cycle plan for the VAMOS effort, and he specifically considers how to integrate Reuse Management processes with existing program management processes.

- **11. The CFRP is a process modeling language with mechanisms to support composition of complex process configurations.**

  Scenario 3 illustrates one aspect of CFRP process modeling when John, who is undertaking an Innovation Exploration task, embeds a P-E-L loop in his activity. Scenario 4 shows more extensive use of CFRP process modeling capabilities. Jack realizes that he cannot plan the reuse program in detail and needs to create lower-level P-E-L loops to do more localized planning. He also uses the notion of cascading C-M-U idioms to understand some of the relationships among stakeholders and recommends that a reuse assessment team produce a more comprehensive stakeholder interaction model. In addition, Jack exploits the CFRP notions of a reuse program, reuse initiative, and reuse cycles to model temporal relationships among distinct phases of the program.

- **12. The CFRP is scalable and applicable at different organizational levels.**

  In scenario 1, Jane applies a CFRP-influenced process at her own individual level, and also uses the CFRP to analyze a reuse plan for a product division. In scenario 3, John and Lee apply the CFRP in a small domain analysis pilot effort, while Kate incorporates the CFRP into her overall project plan. In scenario 4, Jack is planning at a high, strategic level while also "planning the planning" for individual program phases and reuse projects. Jack also identifies several stakeholders in the VAMOS environment, from a variety of organizations and organizational levels.

- **13. The CFRP is a domain model and high level process architecture for the reuse process domain.**

  The central focus of scenario 1 is to use the CFRP as a domain model against which the FPD plan is assessed. In scenario 3, Kate uses the CFRP definition of the Asset Creation family to guide her understanding of the tasks to be planned.

The scenarios also show examples of how the other information included in this document can be used to understand and apply the CFRP. In scenario 1, Jane refers to the diagrams in Appendix A to obtain a more detailed understanding of potential data flows among processes, in preparation for analyzing the reuse plan. In scenario 3, Kate also reviews the diagrams in Appendix A to understand Asset Creation more fully, and John uses Appendix B as a source of information about domain analysis methods that are consistent with the CFRP. In scenario 4, Jack uses Appendix B to find products that can help him define a VAMOS reuse adoption strategy.

4 CFRP Application Experience and Guidelines

Much of this document provides CFRP application guidance that, while grounded firmly in the experience and insight of the document authors, is presented either as theory (the general CFRP application principles in Section 2), interpretation (the example CFRP $IDEF_0$ process model in Appendix A, or instructive fiction (the CFRP application scenarios in Section 3).

This section complements those portions of the document with information that more directly reflects practical experiences with the CFRP. It includes a summary of actual uses of the CFRP to date and provides a preliminary set of practical guidelines for getting started with the CFRP, based on user feedback. This material may be expanded in the future to provide more detail or more definitive guidance.

4.1 Practical Application of the CFRP to Date

Although the scenarios provide coherent stories illustrating how the CFRP can be used, they do not represent case studies describing actual, practical applications of the CFRP. A significant amount of practical CFRP experience is being recorded through both internal STARS efforts and the initiative of external organizations interested in the CFRP. None of that experience has yet been documented in as detailed and coherent a form as the scenarios, so no actual CFRP application efforts are described in detail in this document. Instead, several such efforts are summarized briefly below to help trigger additional ideas for applying the CFRP and to show that the CFRP is proving useful to a number of organizations in a number of ways.

STARS Application

STARS has used the CFRP internally in a wide variety of ways. One approach has been to use the CFRP at a high level as a process checklist or as a means of organizing products. For example, a TRW STARS team compared the processes designated in the CFRP against their reuse-based, risk-driven spiral model for Ada development [Sof91b] to help validate both their model and the CFRP. A joint STARS group used the CFRP to facilitate process planning by identifying which reuse-based process definitions are available today and which process definitions would likely be needed for the STARS demonstration projects (see below). This same group used the CFRP as an organizing principle in packaging STARS and other reuse-related products to support the STARS Reuse Technology Transition Affiliates program (a program being sponsored by STARS to foster trial usage of the packaged products by external organizations and to promote involvement of those organizations in STARS technical activities).

STARS has also applied the CFRP more deeply in a variety of contexts, such as in using the CFRP as a key conceptual foundation for a collection of reuse-based process models. Unisys is defining two process models that are directly derived from or strongly incorporate CFRP principles: the Reuse-Oriented Software Evolution (ROSE) life-cycle process model and the Organization Domain Modeling (ODM) domain analysis process model. The ROSE model [Sof93e] specializes the CFRP and extends it to cover the entire software engineering life cycle to provide specific yet tailorable guidance in the activities that are involved in operating a reuse program in accordance with CFRP principles. ROSE strongly reflects CFRP structure via partitioning into four distinct submodels:

an overall Organization Management process model and Domain Engineering, Asset Management, and Application Engineering project process models. One key emphasis of ROSE is the role of domain-specific reuse and re-engineering on software maintenance and evolution. The ODM model [Sof93a] directly integrates the CFRP idioms with a variety of modeling principles and techniques to form a set of processes that encompass both the planning activities involved in selecting and scoping domains of focus, and the domain engineering activities involved in creating and evolving domain models and asset bases. ODM is also generally consistent with the ROSE model so that ODM can be readily applied in the ROSE context.

Boeing has led development of a STARS Reuse Strategy Model [Sof93c] that will enable projects to assess their reuse capabilities and devise strategies for evolving them. The specific capability dimensions and indicators in the model are strongly influenced by the CFRP. Furthermore, part of the plan for future evolution of the RSM is to use the CFRP as a domain model of reuse processes that provides a classification structure for collecting and comparing data, metrics, and experience about reuse processes and practices. This information will be used to evolve the RSM over time based on empirical evidence. The Boeing STARS team has also used the CFRP as a basis for a process model that extends domain engineering concepts to address reuse-based product line management [DB92].

The principal thrust of the STARS program at this time is to support the STARS demonstration projects. STARS is working with the Army, Navy, and Air Force to sponsor three DoD software engineering projects, with the objective of demonstrating the benefits of the megaprogramming paradigm in a realistic and familiar context. Each of these projects provides an important setting in which to apply the CFRP to reuse planning. To date, the Army STARS Demonstration Project, supported by Unisys, has applied the CFRP most directly to their planning processes. The project focus is on re-engineering an Army Intelligence Electronic Warfare (IEW) application while simultaneously engineering a set of domain assets within a subset of that application area that will be reusable across multiple IEW applications. The project has been strongly influenced by CFRP Plan-Enac ,earn principles, as seen not only in their process model definitions, but also in the way they have ..ghtly woven those principles into their daily work. The project thus far has focused on using the CFRP as a guideline for structuring their high-level project processes, while using ODM as the basis for their lower-level domain engineering processes. The project is now beginning to use the ROSE model as a basis for modeling portions of their overall project processes at a finer level of granularity than the CFRP offers, while retaining consistency with ODM.

Non-STARS Application

The CFRP is also being used in various contexts not directly associated with STARS activities. A reuse initiative within a Boeing Commercial Airplane group has incorporated key concepts of the CFRP, particularly the notion that reuse requires planning, investment, and management of software as assets. The CFRP has also influenced the design of a Boeing-developed Cobol Reengineering Workbench to provide reverse engineering capabilities that support domain analysis. The Air Force Central Archive for Reusable Defense Software (CARDS) program, which is already a key trial user of STARS technology, has evaluated and, to varying degrees, used the CFRP as an organizing principle for some of their reuse products and training materials. The Air Force has also used the CFRP as a basis for organizing aspects of their Software Reuse Implementation Plan. The Institute for Defense Analyses (IDA), on behalf of the DoD, has used the CFRP structure as

a means for organizing information that is being collected to characterize reuse success stories in government and industry.

Hewlett-Packard, a Unisys STARS Prime Affiliate and STARS Reuse Technology Transition Affiliate, has begun using the CFRP internally in two activities. In one, a product-development organization is analyzing its current software development process, then developing an improved process based on integrating the CFRP model with the existing process. Participants are receiving training to better understand the CFRP, as well as training in process analysis and modeling. In the other project, the centralized corporate organization that provides expertise in software reuse has developed a general reuse process model. They have used the CFRP as a checklist, against which to evaluate and improve the general reuse process. This model is the basis for training in reuse concepts and hands-on training in asset engineering activities.

4.2 Getting Started with the CFRP

Early feedback from CFRP application efforts has suggested several preliminary hints and guidelines for getting started with the CFRP. These are described concisely below.

Prospective users of the CFRP, after absorbing the CFRP Definition and Application documents, should be able to approach reuse tasks with a more comprehensive view of what process-driven, domain-specific reuse entails. Nevertheless, the CFRP Application document, if taken strictly at face value, provides only a limited perspective on how to apply the CFRP, since it covers only a fraction of the tasks and situations to which the CFRP can be applied. Readers must be prepared to abstract and interpret the material in the document (particularly the scenarios) to understand how to apply the CFRP in their own contexts. The role of the scenarios is thus mainly to inspire CFRP insights among prospective users in preparation for their own specific reuse tasks. Regardless of the nature and size of these tasks, we encourage readers to view their reuse work through CFRP-tinted glasses and "live" the CFRP in their own activities.

Of course, learning to apply the CFRP will require not only philosophical insights and perspectives, but also experience gained through practical use. We suggest applying the CFRP gradually within an organization, in incremental steps. This can involve starting with a small scale effort that does not address all aspects of the CFRP and gradually broadening the scope of the work as appropriate. It is vital in such contexts not to downplay the importance of Reuse Management. In particular, incremental approaches demand that objectives be established, results be measured and evaluated, and lessons be learned to fuel improvement.

One approach is to start with a personal pilot effort. An individual interested in introducing the CFRP within an organization could use a small pilot as an opportunity to get a hands-on appreciation for the benefits of the CFRP and develop confidence in applying it. Interpreting an existing reuse effort in CFRP terms, as done in scenario 1, could be a suitable pilot. Writing a plan for an envisioned reuse project within one's organization could be another. A more ambitious pilot would involve planning and enacting small Create, Manage, and/or Utilize efforts and learning from them.

Experience with the CFRP has suggested some guidelines for applying the CFRP in detail. One guideline is to recognize that the CFRP is a high level framework and often open to different, yet

equally valid, interpretations. In trying to map a given activity to the CFRP, there may be several reasonable alternatives, and none of them may be clearly the "best", due to conflicting criteria or interpretations. In such circumstances, we recommend simply picking one option and not agonizing over the choice. The choice can always be refined later with the benefit of experience and learning. Another guideline is to be cautious about creating too many nested layers of P-E-L loops within CFRP models, because such models can easily become large, complex, and difficult to understand. Each P-E-L loop should have a scope or time frame that is clearly different from its parent loop.

It is unclear whether in the long run the CFRP will be applied directly, as in the illustrative scenarios in this document, or whether the CFRP concepts and structures will be built into less abstract process models and methodologies that are applied in practice. In the latter case, the CFRP would provide the conceptual foundation, but would not be used as the primary source of information. We invite feedback from any use of the CFRP to help shape its further development and to indicate the type of application guidance that will be most valuable.

A CFRP $IDEF_0$ Process Model

This appendix provides an example of how the CFRP can be modeled using the $IDEF_0$ notation. It includes a set of $IDEF_0$ diagrams, followed by a data dictionary that describes the meaning of each of the data items flowing between process categories in the diagrams.

A.1 $IDEF_0$ Diagrams

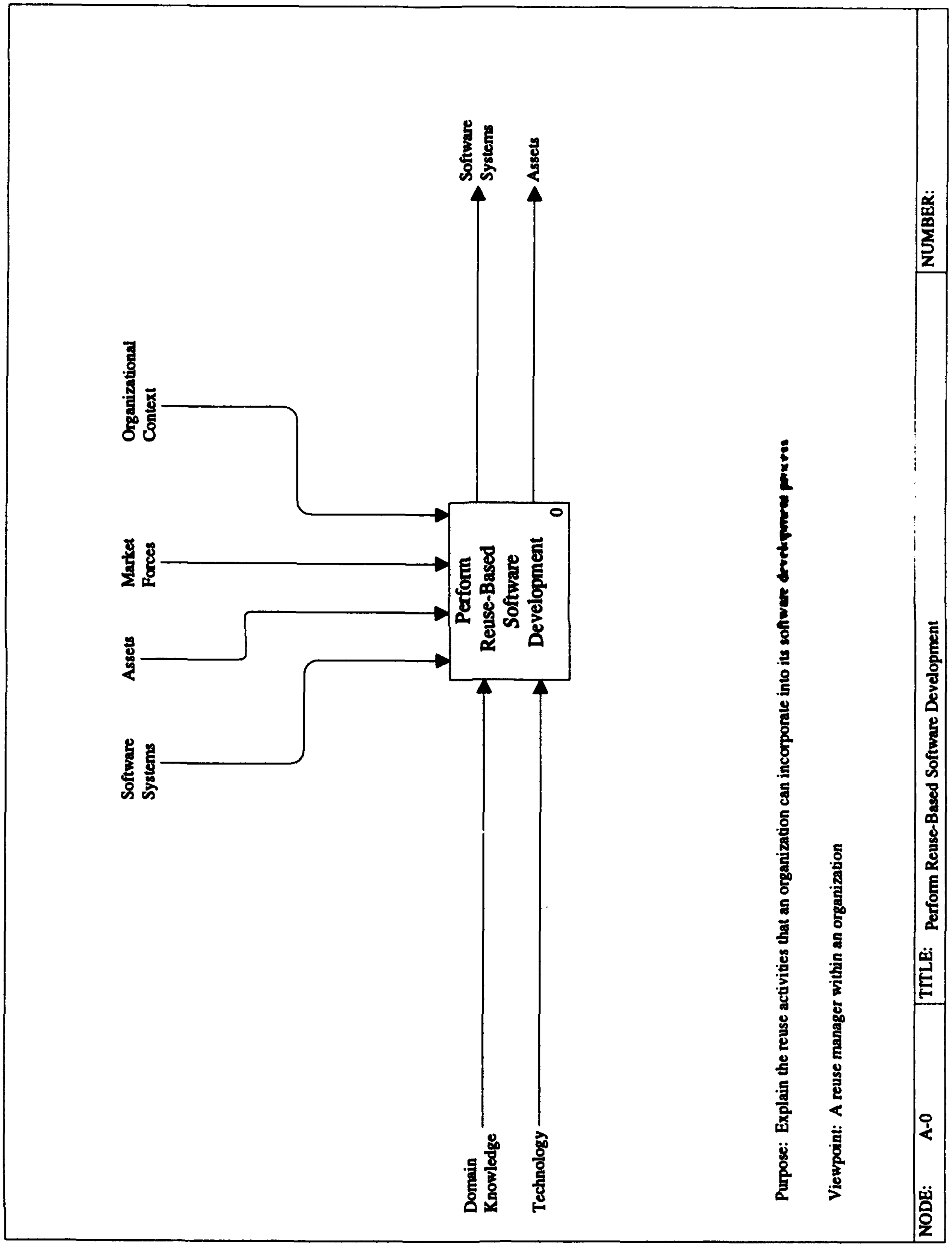
The $IDEF_0$ process model diagrams appear on the pages that follow. The order in which the diagrams appear is consistent with the hierarchical idiom/family decomposition structure of the CFRP and should be straightforward to follow. The only deviation from the CFRP family structure is that the Asset Management process family is broken into two diagrams, a *Manage Assets* diagram that encompasses all of Asset Management, and a *Populate Library* diagram that focuses on the Asset Management activities associated with populating an asset library with individual assets.

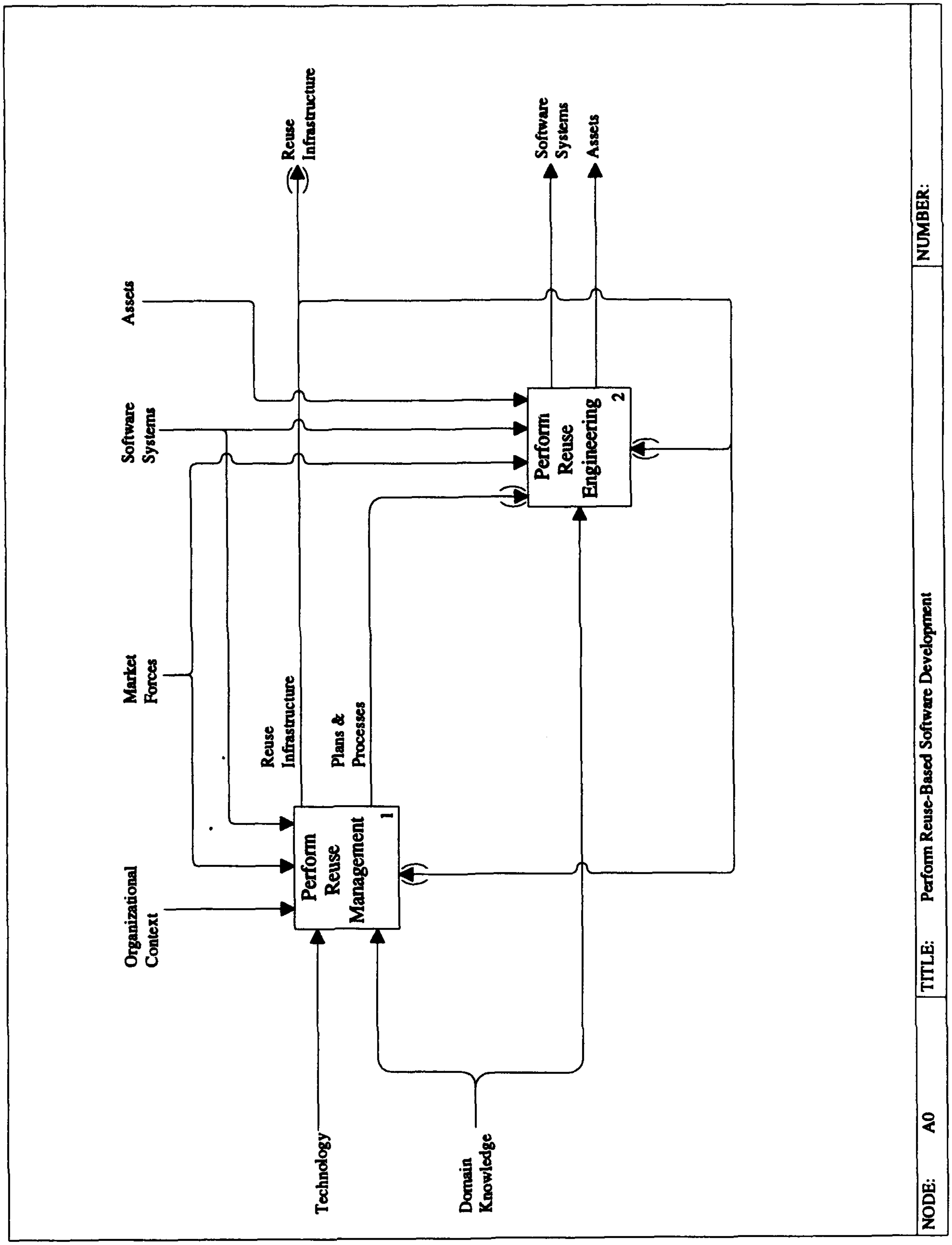
The process categories and data flows in this $IDEF_0$ model illustrate one interpretation of the CFRP, designed to be highly consistent with the canonic CFRP as described in the CFRP Definition document. Organizations can use this model directly as a basis for additional $IDEF_0$ CFRP modeling (e.g., modeling the CFRP in more detail or modeling alternative CFRP configurations). They can also adapt the process categories and data flows to address their specific needs, while still conforming to the CFRP process idiom and family structure, or they can integrate the model (or some adaptation thereof) with existing $IDEF_0$ process models.

$IDEF_0$ is becoming an increasingly popular process modeling notation, but not all readers of this document may be familiar with it. The following is a brief overview of the notation:

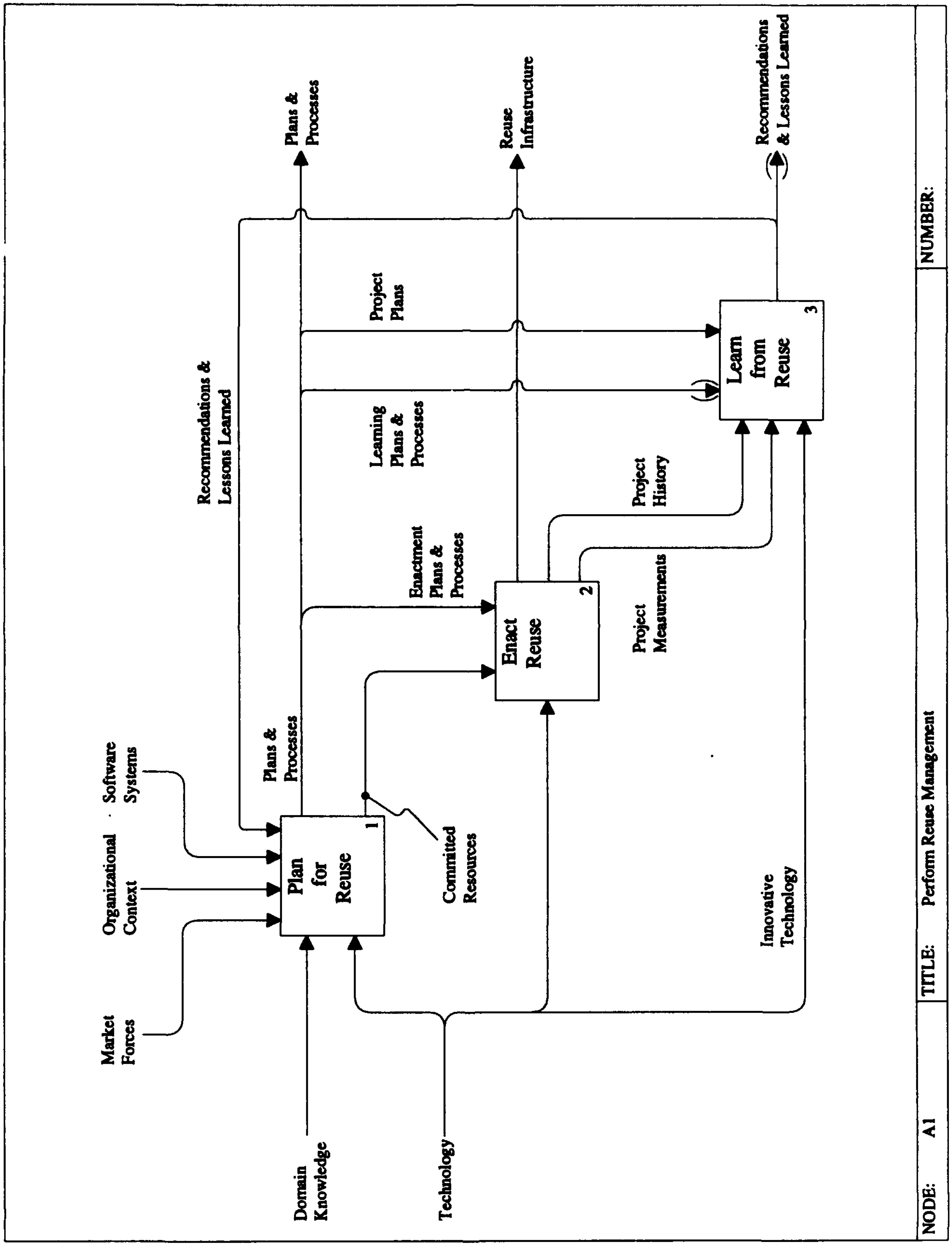
> An $IDEF_0$ activity diagram contains one level of decomposition of a process. Boxes within a diagram show the subactivities of the parent activity named by the diagram. Arrows between the boxes show the flow of information among activities. Arrows entering the left side of a box are inputs to an activity, arrows exiting the right side of a box are outputs from the activity, arrows entering the top of a box are controls that regulate the activity, and arrows entering the bottom of a box are mechanisms that support the activity. A sequential ordering of boxes in a diagram implies some information flow dependency between the activities, but does not imply a sequential flow of control between the activities. Any activity can be further decomposed into another $IDEF_0$ diagram describing its subactivities.

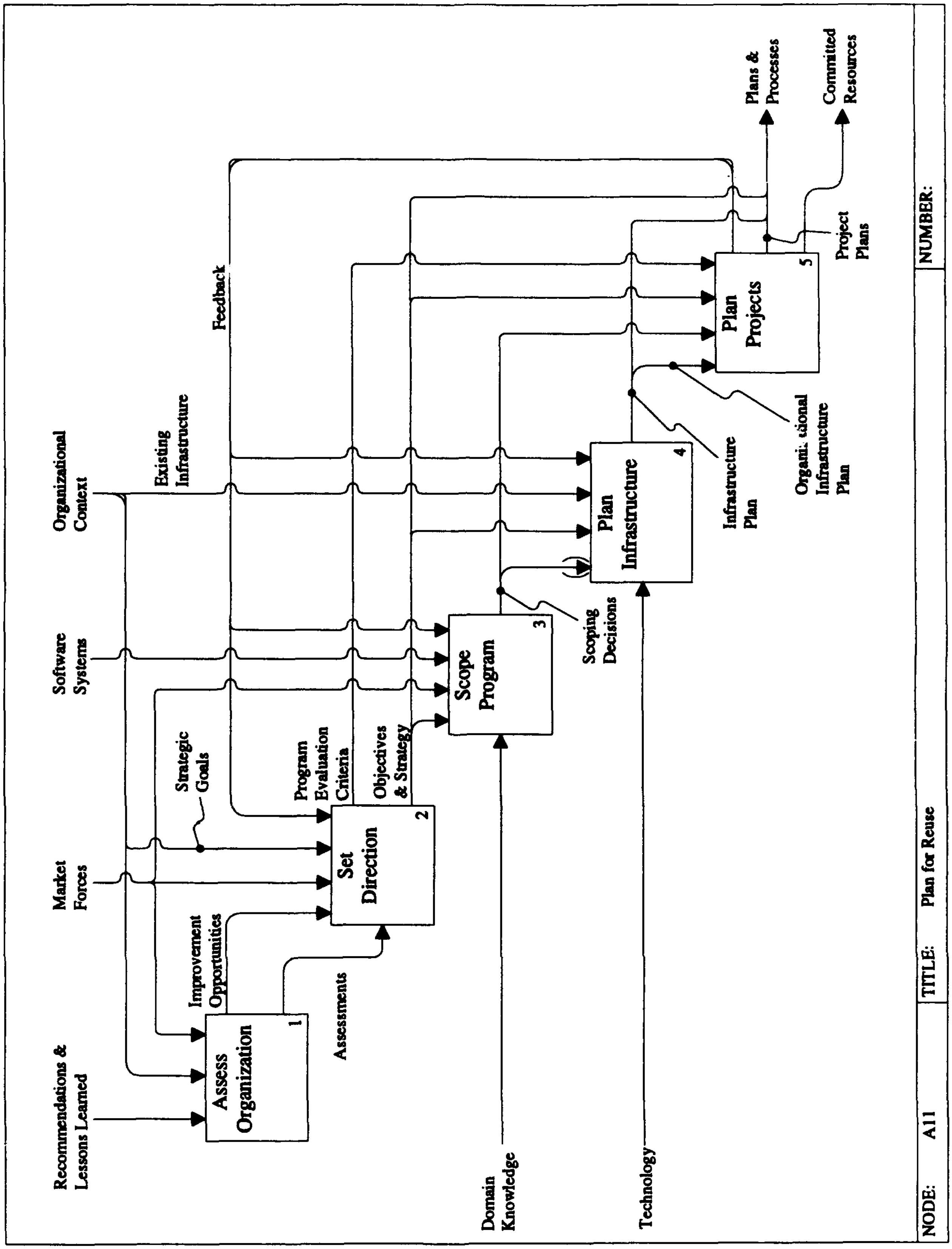
See [Sof81] for more details on the notation syntax and semantics.


Organizational Context
Market Forces
Assets
Software Systems
Perform Reuse-Based Software Development
0
Software Systems
Assets
Domain Knowledge
Technology
Purpose: Explain the reuse activities that an organization can incorporate into its software development process
Viewpoint: A reuse manager within an organization
NODE: A-0
TITLE: Perform Reuse-Based Software Development
NUMBER:

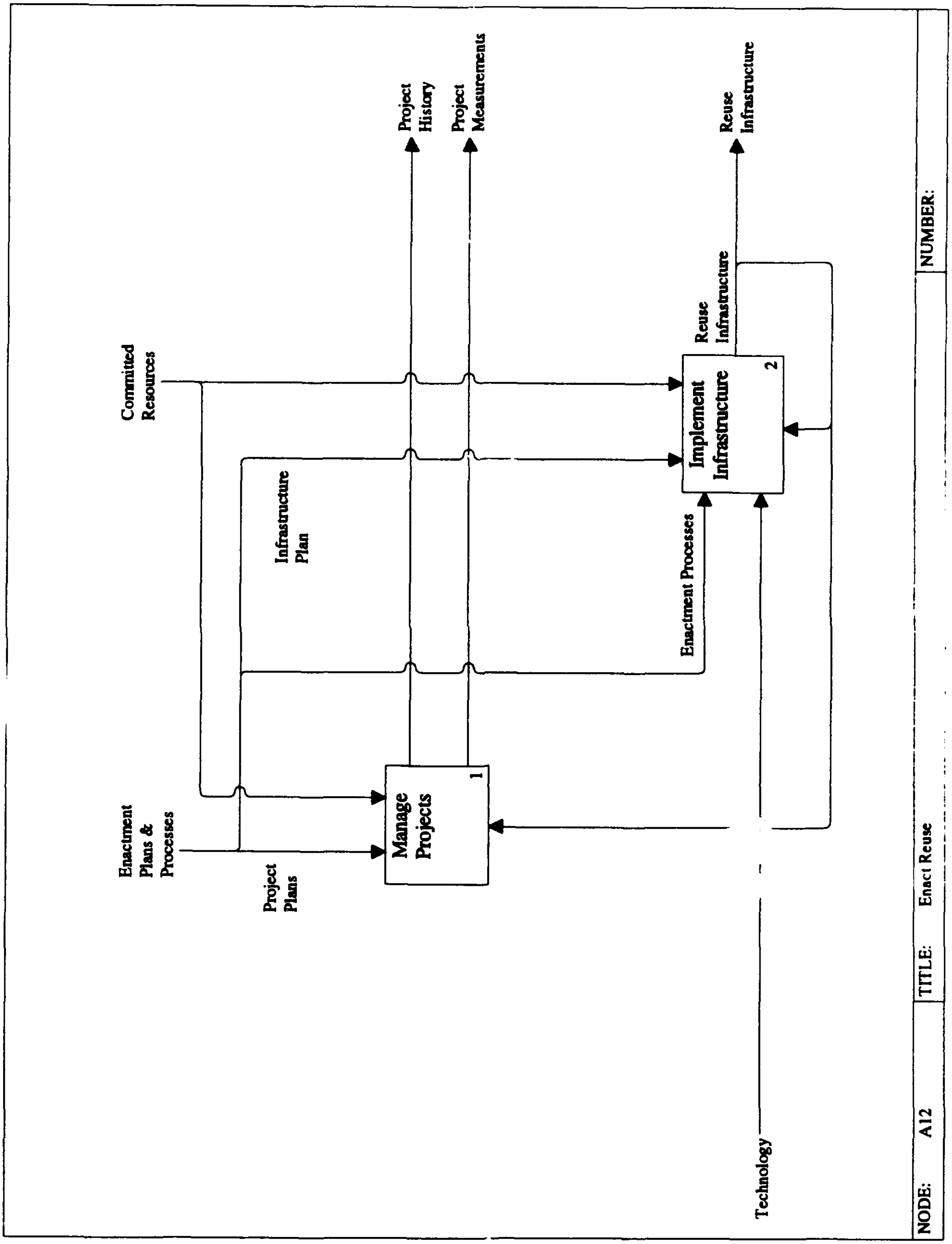


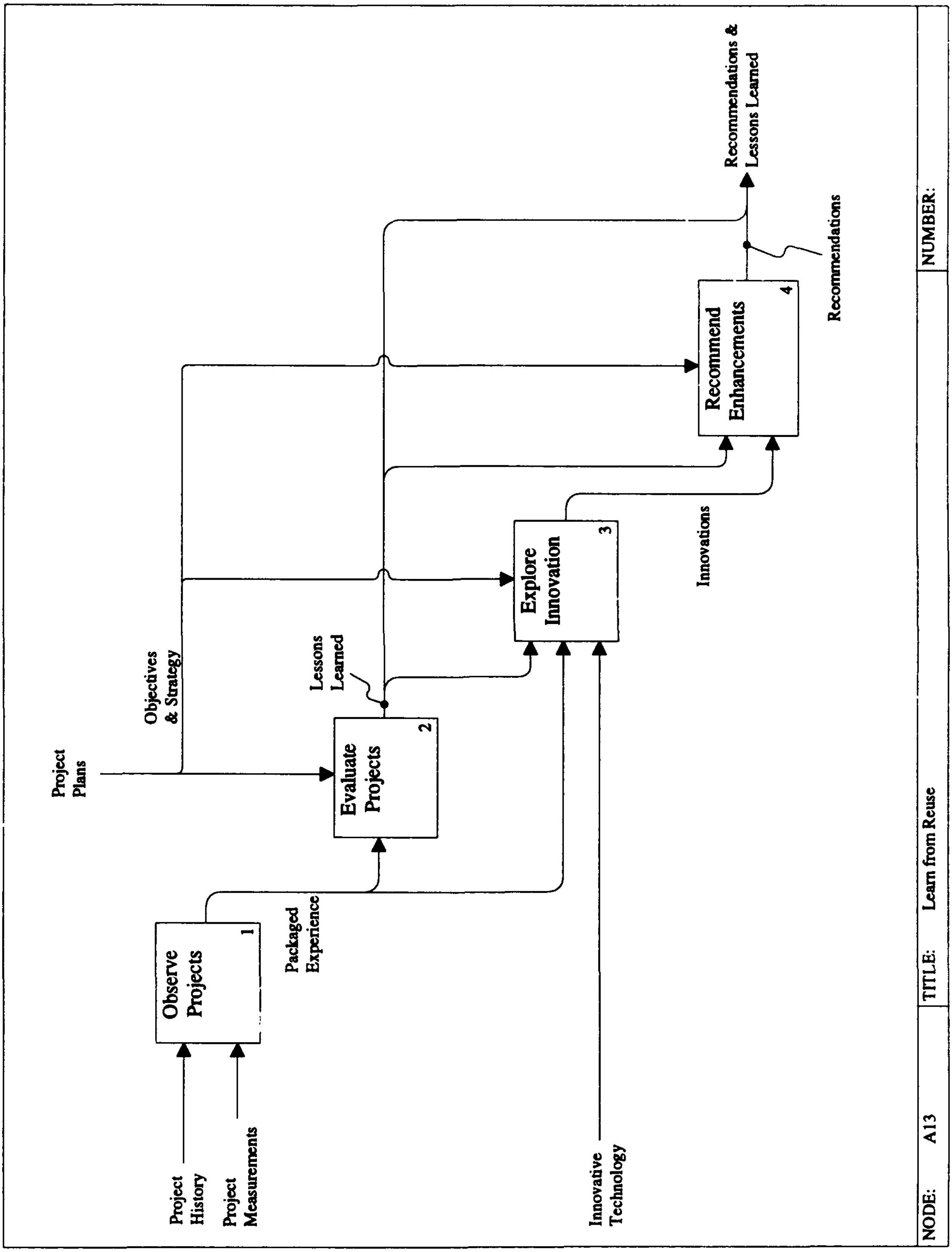
Organizational Context
Market Forces
Software Systems
Assets
Reuse Infrastructure
Software Systems
Assets
Reuse Infrastructure
Plans & Processes
Perform Reuse Management
1
Perform Reuse Engineering
2
Technology
Domain Knowledge
NODE: A0
TITLE: Perform Reuse-Based Software Development
NUMBER:


Market Forces
Organizational Context
Software Systems
Domain Knowledge
Technology
Plan for Reuse
1
Committed Resources
Plans & Processes
Recommendations & Lessons Learned
Enact Reuse
2
Enactment Plans & Processes
Project Measurements
Project History
Learning Plans & Processes
Project Plans
Learn from Reuse
3
Innovative Technology
Plans & Processes
Reuse Infrastructure
Recommendations & Lessons Learned
NODE: A1
TITLE: Perform Reuse Management
NUMBER:

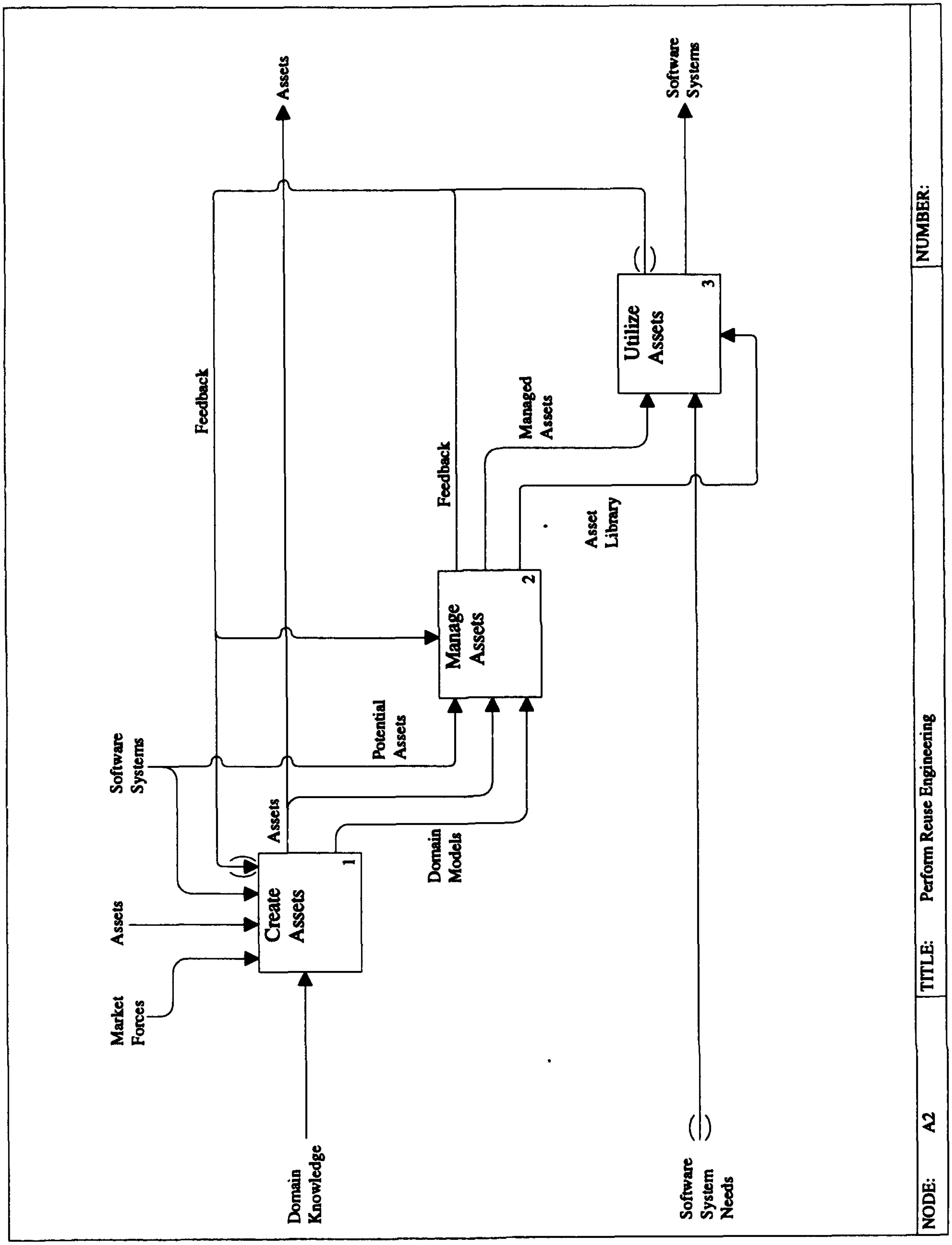


Recommendations & Lessons Learned
Market Forces
Software Systems
Organizational Context
Existing Infrastructure
Feedback
Strategic Goals
Program Evaluation Criteria
Objectives & Strategy
Improvement Opportunities
Assessments
Assess Organization
1
Set Direction
2
Scope Program
3
Plan Infrastructure
4
Plan Projects
5
Scoping Decisions
Infrastructure Plan
Organizational Infrastructure Plan
Project Plans
Plans & Processes
Committed Resources
Domain Knowledge
Technology
NODE: A11
TITLE: Plan for Reuse
NUMBER:

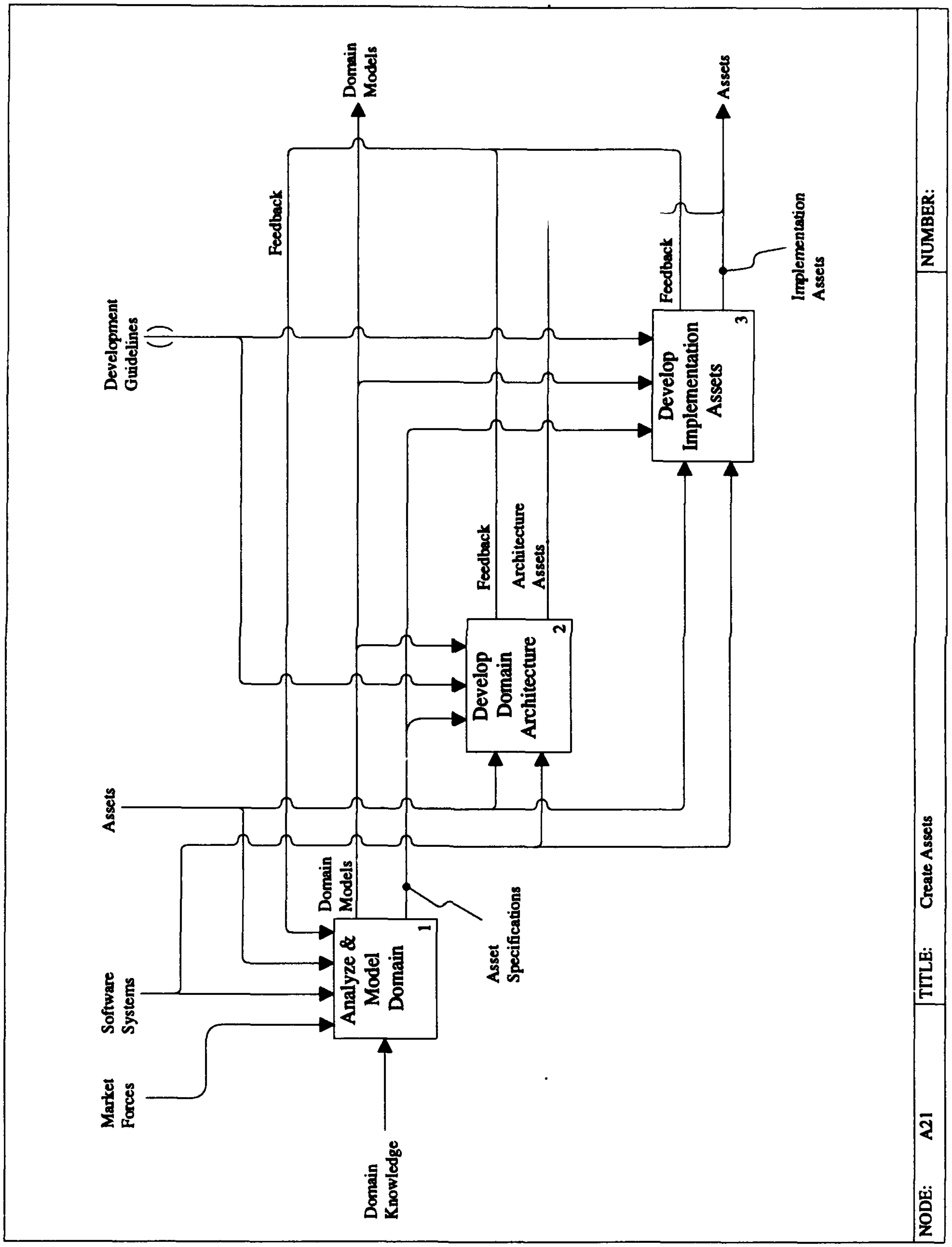

Commited Resources
Enactment Plans & Processes
Project Plans
Infrastructure Plan
Enactment Processes
Manage Projects
1
Implement Infrastructure
2
Project History
Project Measurements
Reuse Infrastructure
Reuse Infrastructure
Technology
NODE: A12
TITLE: Enact Reuse
NUMBER:

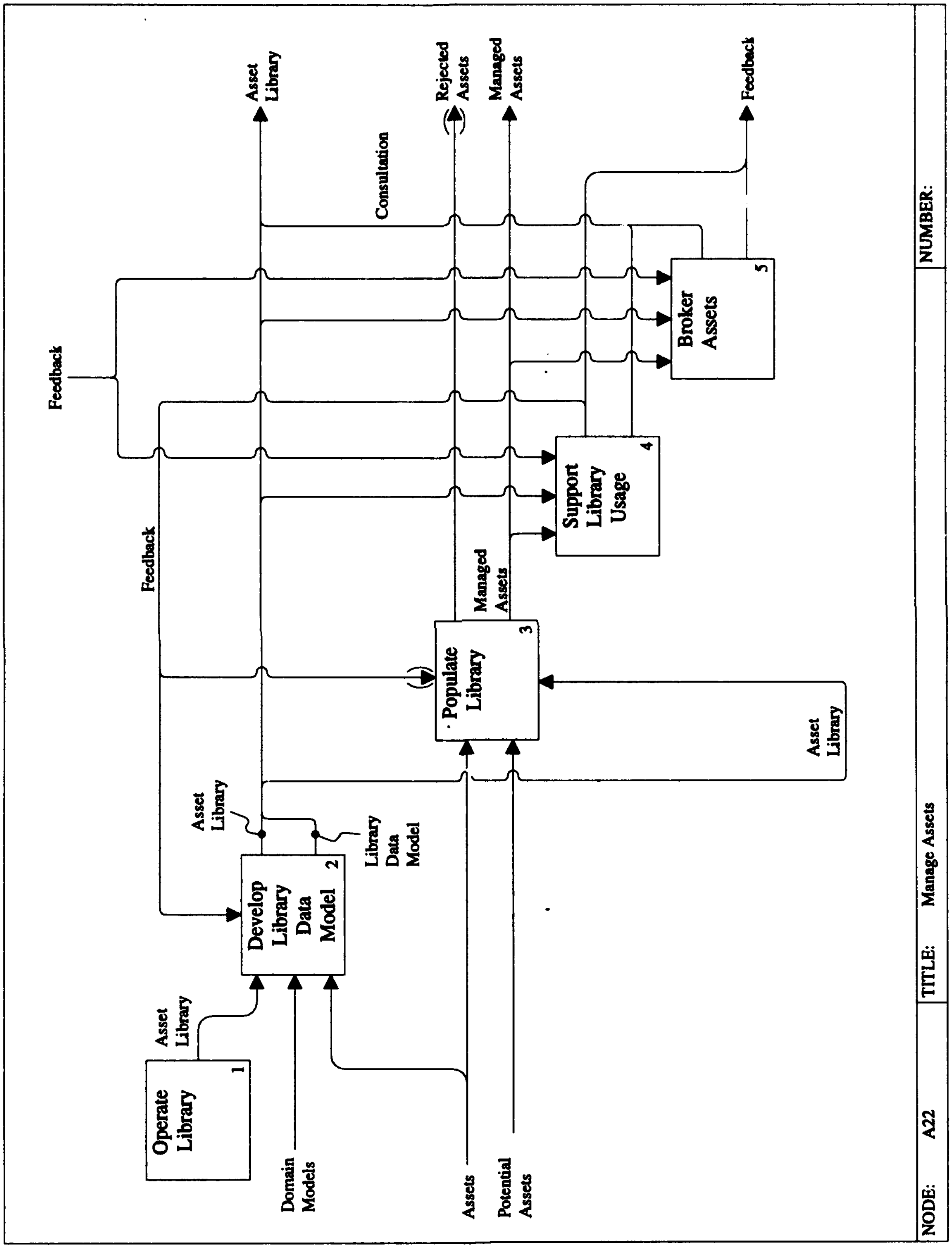


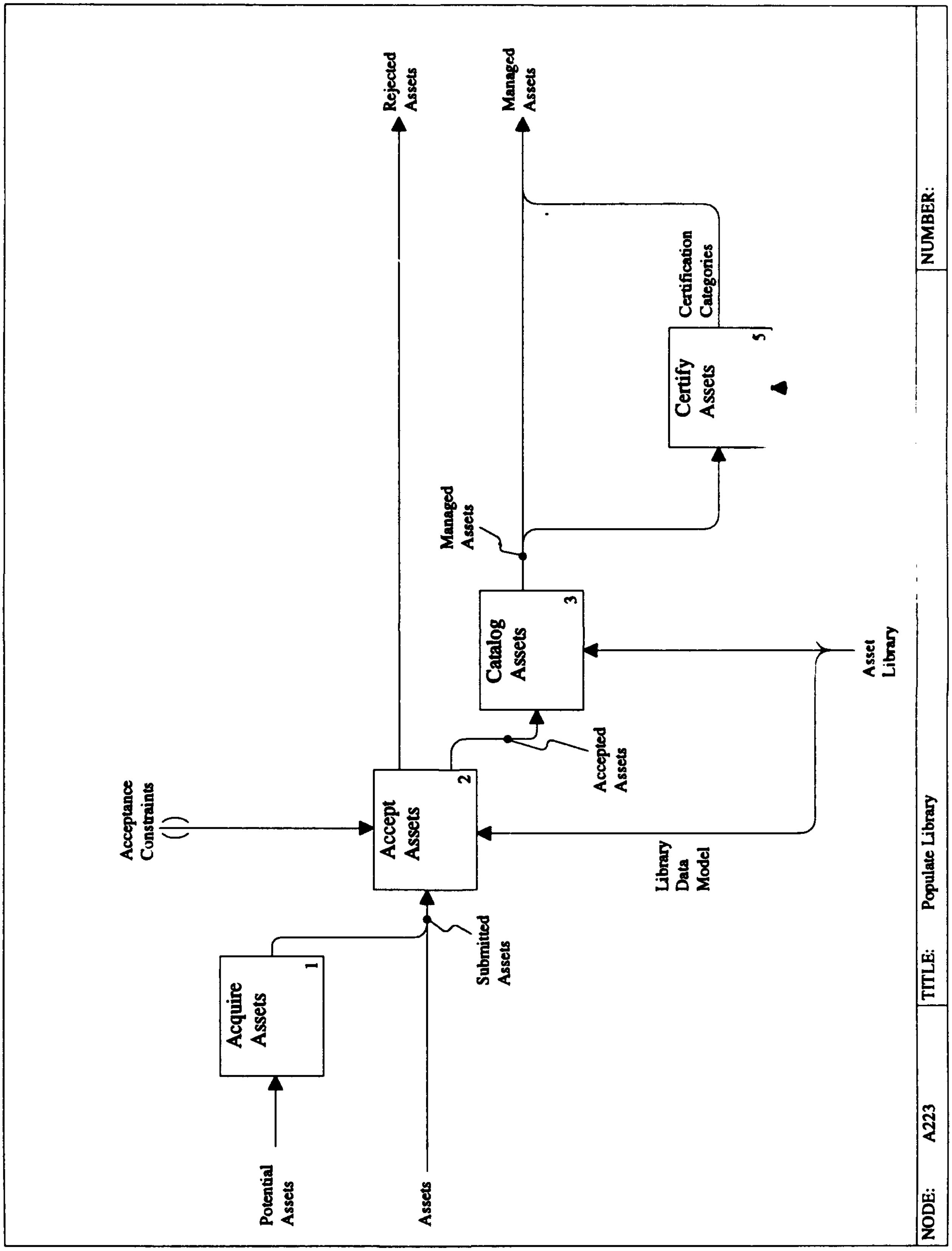
Project History
Project Measurements
Observe Projects
1
Packaged Experience
Project Plans
Evaluate Projects
2
Objectives & Strategy
Lessons Learned
Innovative Technology
Explore Innovation
3
Innovations
Recommend Enhancements
4
Recommendations
Recommendations & Lessons Learned
NODE:
A13
TITLE:
Learn from Reuse
NUMBER:

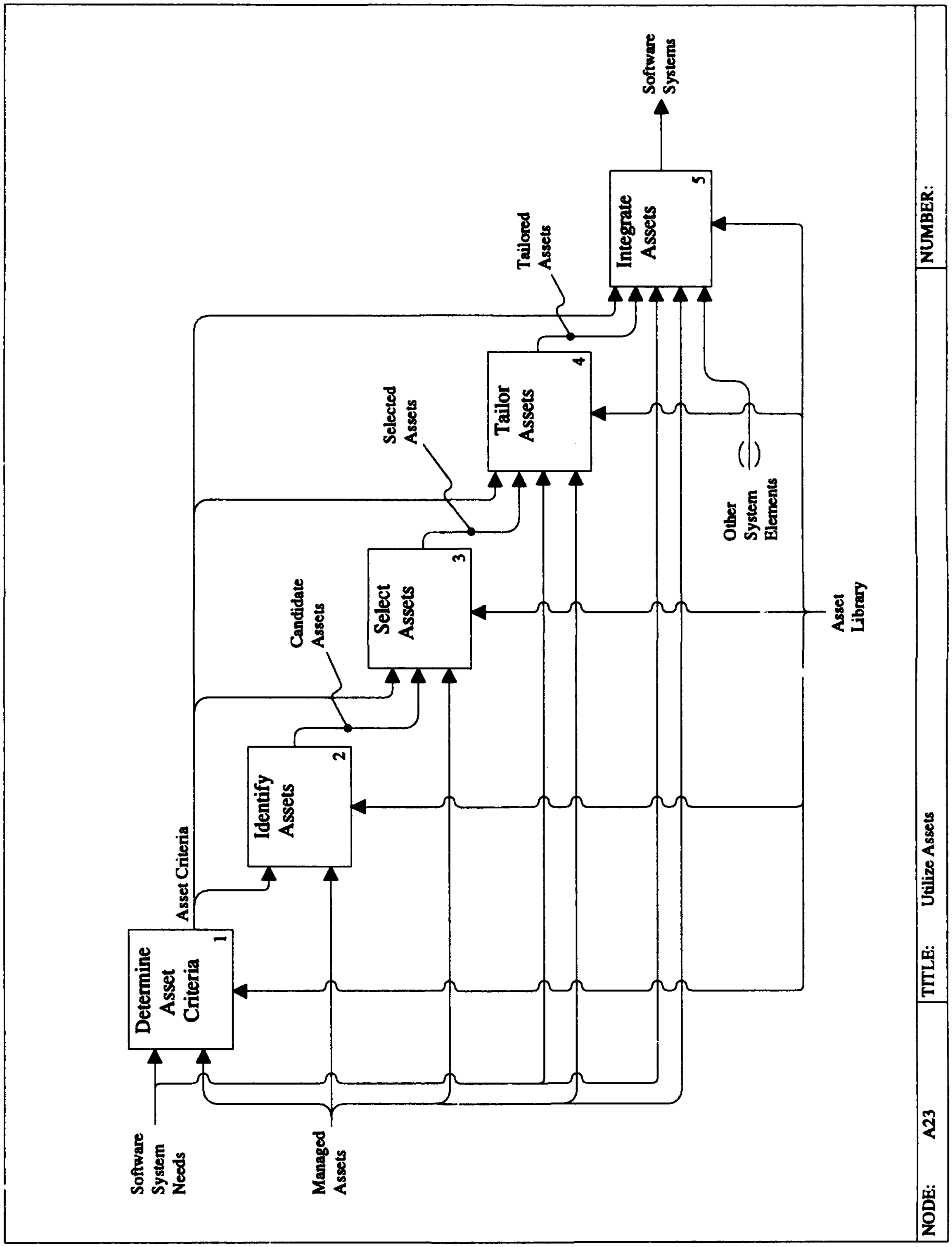


Market Forces
Assets
Software Systems
Domain Knowledge
Create Assets
1
Assets
Domain Models
Potential Assets
Manage Assets
2
Feedback
Feedback
Assets
Managed Assets
Asset Library
Utilize Assets
3
Software Systems
Software System Needs
NODE:
A2
TITLE:
Perform Reuse Engineering
NUMBER:


Domain Knowledge
Market Forces
Software Systems
Assets
Development Guidelines
Analyze & Model Domain
1
Domain Models
Asset Specifications
Feedback
Develop Domain Architecture
2
Feedback
Architecture Assets
Develop Implementation Assets
3
Feedback
Implementation Assets
Domain Models
Assets
NODE: A21
TITLE: Create Assets
NUMBER:


Operate Library 1
Develop Library Data Model 2
Populate Library 3
Support Library Usage 4
Broker Assets 5
Asset Library
Domain Models
Assets
Potential Assets
Library Data Model
Feedback
Consultation
Rejected Assets
Managed Assets
NODE: A22
TITLE: Manage Assets
NUMBER:


Potential Assets
Acquire Assets 1
Assets
Submitted Assets
Acceptance Constraints
Accept Assets 2
Library Data Model
Accepted Assets
Catalog Assets 3
Asset Library
Managed Assets
Certify Assets 5
Certification Categories
Rejected Assets
Managed Assets
NODE: A223
TITLE: Populate Library
NUMBER:


Determine Asset Criteria
1
Identify Assets
2
Select Assets
3
Tailor Assets
4
Integrate Assets
5
Software System Needs
Managed Assets
Asset Criteria
Candidate Assets
Selected Assets
Tailored Assets
Software Systems
Other System Elements
Asset Library
NODE: A23
TITLE: Utilize Assets
NUMBER:

A.2 Data Dictionary for IDEF$_0$ Diagrams

The following data dictionary contains a description of the inputs, outputs, controls, and mechanisms in the IDEF$_0$ diagrams. Descriptions of the processes can be found in the CFRP Definition document.

Acceptance Constraint A policy, legal, or domain-specific constraint that must be satisfied by a submitted asset to be accepted for inclusion in the asset library.

Accepted Asset A submitted asset that satisfies all acceptance constraints for inclusion in the asset library.

Architecture Asset A reusable software architecture applicable to multiple systems within a domain. The architecture defines an organizing framework for constructing new application designs and implementations.

Assessment A characterization of the current state of reuse practice within a reuse program's scope of planning, the readiness of the organization as a whole (or of specific groups) for practicing reuse-based software engineering, and the reuse technology and expertise available both internal and external to the organization.

Asset A unit of information of current or future value to a software development or maintenance enterprise. Assets can include a wide variety of items, such as software life cycle products, domain models, processes, documents, case studies, research results, presentation materials, etc.

Asset Criteria Criteria for identifying, selecting, and tailoring assets in order to reuse them for some purpose.

Asset Library A set of assets and associated services for accessing and reusing the assets. A library typically consists of assets, corresponding asset descriptions, a library data model, and a set of services (manual or automated) for managing, finding, retrieving, and reusing assets. Such services can include reuse consultation services.

Asset Specification A specification describing the characteristics of assets that are to be implemented. Assets are specified in terms of the range of features or characteristics they should support. The methods and technologies that should be used to develop the assets may also be specified.

Candidate Asset An asset that has been identified as a candidate for reuse in accordance with some asset criteria.

Certification Category A category to which an asset is assigned to indicate the degree of confidence that has been established about the asset relative to some set of criteria, such as functional correctness, reliability, and adherence to standards.

Committed Resources Items of value that are allocated to support reuse projects, such as funding, staffing, needed expertise, and technology to be acquired.

Consultation A service provided to assist a user of an asset library in using the library tools, locating needed assets, reusing the assets, etc.

Development Guidelines Guidelines followed during Asset Implementation to increase the likelihood that the assets will be reusable and of high quality. These development guidelines should emphasize good software engineering practices and principles.

Domain Knowledge Information about a domain in a form other than legacy systems. This knowledge can be imparted in a variety of ways.

Domain Model A definition of the characteristics of existing and potential future products within a domain in terms of what the products have in common (their "commonality") and how they may vary (their "variability").

Enactment Plan The portion of a plan defined in Project Planning that specifically addresses and constrains Reuse Enactment activities. The enactment plan defines program objectives, target domains, measurement criteria, and individual project and infrastructure plans.

Enactment Process A process defined in Project Planning that is specifically enacted to perform Reuse Enactment activities.

Existing Infrastructure The infrastructure already in existence during the planning activities of a reuse program.

Feedback Reactions and lessons learned from the use of the reuse program's assets, plans, and services. This feedback can include information about shortcomings in reuse plans, Asset Management services, domain models, and domain architectures and other assets.

Implementation Asset Any asset (other than an architecture asset) applicable to the implementation of multiple systems within a domain. The asset can be a *component* (i.e., reusable directly to form an application product, perhaps with some tailoring) or a *generator* (i.e., a tool that generates application products based on a specification of desired product characteristics).

Improvement Opportunity An opportunity for improving the current state of the reuse program, based on recommendations and lessons learned from the Reuse Learning activities and insights gained during Assessment activities.

Infrastructure Plan A plan for meeting the common technical, organizational, and educational needs for all projects within the current scope of planning.

Innovation New ideas, discoveries, and innovative products that can improve the processes, infrastructure, or assets within the reuse program.

Innovative Technology Technology of a new or innovative nature (relative to a given organization), available from external sources such as the research community, marketplace, or publicly available asset bases.

Learning Plan The portion of a plan defined in Project Planning that specifically addresses and constrains Reuse Learning activities.

Learning Process A process defined in Project Planning that is specifically enacted to perform Reuse Learning activities.

Lessons Learned Results of Project Evaluation, propagated and possibly filtered by Enhancement Recommendation, that reflect what has been learned about a project during its enactment.

Library Data Model A data model for describing assets in an asset library. The model should include the information that most directly and appropriately supports the Asset Utilization processes of prospective library users (and it should structure the information accordingly).

Managed Asset An asset that has been incorporated into the library and made accessible to library users. A managed asset has an accompanying asset description containing information about the asset that aids user understanding and evaluation of the asset.

Market Forces New market trends, competitive developments, new technologies, emerging standards, and other factors that impact perception of marketplace needs.

Objectives Specific reuse objectives defined for the reuse program as a whole.

Organizational Context The business strategies, policies and procedures, expertise, technological capabilities, cultural legacies, etc., of the set of organizations involved in a reuse effort.

Organizational Infrastructure Plan A plan for meeting the common organizational needs for all projects planned within a reuse program. Organizational infrastructure can include coordinated team activities, funding models, incentive strategies, risk reduction measures, organizational policies and procedures, project role definitions, reuse-oriented task forces, transition teams and steering committees, and so on.

Other System Element An application system element, not derived from a reusable asset, with which tailored assets are integrated.

Packaged Experience Project measurement and history data that has been packaged into structured knowledge to facilitate systematic learning.

Plan A reuse program plan, including explicit objectives and strategic decisions, target domains and other scoping decisions, proposed reuse infrastructure capabilities to be acquired or developed, reuse projects and project interrelationships to perform the proposed work, and criteria and metrics for evaluating the success of the program.

Potential Asset An artifact obtained from some relevant source (e.g., another asset library, an existing software system within a relevant domain) that is a candidate for inclusion in an asset library.

Process A description of a series of steps, actions, or activities to bring about a desired result. The process may be expressed at various levels of abstraction. reflecting the various degrees of precision appropriate at different organizational levels and at different stages in the definition of a overall life cycle process. Depending on the level of abstraction at which a process is described, it may or may not include well-defined inputs, intermediate products, constraints, needed resource descriptions, outputs, and testable criteria for starting, stopping, and moving on to the next step in the series.

Program Evaluation Criteria The criteria for evaluating how successfully a reuse program's objectives have been met.

Project History Qualitative historical information about the project processes, products, and infrastructure.

Project Measurement A quantitative measurement collected during project enactment to measure the effectiveness of the project processes and reuse infrastructure, as well as the quality of the products produced by the processes and infrastructure.

Project Plan A detailed plan of the Reuse Engineering projects that will be enacted within a reuse program. The project plan includes the identity of the individual projects and specification of the relationships and interconnections among the projects. It also includes definitions of the specific processes, evaluation metrics, budget, schedules, resource needs, and potential payoff for each project.

Recommendation A suggestions for changes to the reuse program strategy or plans, reuse infrastructure, reuse processes, or reuse products, based on the results of learning.

Rejected Asset A submitted asset that does not satisfy all library acceptance criteria and is therefore rejected for inclusion in the asset library.

Reuse Infrastructure The collection of capabilities that is needed to support and sustain reuse projects within a reuse program. Includes tools and technology; organizational structure, policies and procedures; and education and training.

Scoping Decision A decision about the overall scope of a reuse program. Such decisions can involve selection of application product lines to be produced based on domain assets, selection of specific domains that will be engineered to support the product lines, identification of specific client or stakeholder groups for the engineered domains, more traditional definition of engineering scope for individual tasks, etc.

Selected Asset An asset selected for reuse in accordance with some asset criteria.

Software System A software application system encompassing one or more domain(s) of interest.

Software System Needs Overall application system requirements including user requirements and any reuse-related requirements governing specific asset characteristics.

Strategic Goals Goals determined by the high-level strategies within a reuse program.

Strategy An approach to instituting and evolving reuse capabilities to satisfy overall objectives within a reuse program. The strategy is generally targeted to address specific domains.

Submitted Asset An asset or candidate asset that is submitted for inclusion in the asset library.

Tailored Asset An asset which has been adapted for integration into a desired application product.

Technology Technological capabilities that can contribute to the reuse infrastructure within an organization and can be applied to establish or automate reuse processes.

B A Mapping of Existing Reuse Products to the CFRP

This appendix identifies a list of products (processes and tools) that support reuse activities identified in the CFRP and maps those products to each of the six CFRP process families to which they are applicable. The purpose of this appendix is to give the CFRP user an indication of the kinds of products that are available to support different aspects of reuse activity and to provide some specific pointers to products to consider during project planning, process engineering, and infrastructure planning and implementation.

This appendix consists of two tables, one containing only STARS products (including ASSET products) and the other containing non-STARS products. These tables are subject to the following caveats and disclaimers:

- Inclusion of a product in the table of non-STARS products should not be construed in any way as a STARS endorsement of the product.
- The set of products presented here is considered to be representative of products available in the commercial and government marketplace, but it should not be construed in any way as being complete. Additional products will be added in future versions of this document as the authors become aware of them and as resources permit.
- In general, the specific mapping of the products to CFRP process families has not been verified with the product developers and reflects only the authors' assessments at this time.
- One general criterion for including a product in this appendix was general public availability, but the authors do not guarantee availability of the products.
- Another criterion for whether or not to include a product in this appendix is that a product should not be included if it can be used effectively in a context where reuse is not a principal objective. This excludes general object-oriented analysis and design methods, for example.

In each table, the leftmost column includes the product name. Where appropriate, at the end of each product name there is a reference to one or more documents that comprise or describe the product. These references point to bibliographic entries in the References section at the end of this document. The second column in each table includes the source of each product, i.e., the organization or program that produced the product. The third column includes the product type, with values defined as follows:

- *process* – a textual and/or graphical representation of a paradigm, framework, methodology, process description, policy, etc.
- *tool* – an executable software product that provides automated support for one or more reuse processes.

The other columns in the tables correspond to the CFRP process families, and an "x" in a column implies that a product is applicable to that family.

B.1 STARS Products

			Reuse Management			*Reuse Engineering*		
Product	*Source*	*Type*	*Plan*	*Enact*	*Learn*	*Create*	*Manage*	*Utilize*
Reuse Strategy Model (RSM) [Sof93c]	STARS	process	x		x			
Reuse-Oriented Software Evolution (ROSE) [Sof93e]	STARS	process	x	x	x	x	x	x
Reuse-Based Spiral Life-Cycle Process [Sof91b, Sof91d]	STARS	process	x	x				x
Organization Domain Modeling (ODM) [Sof93a]	STARS	process	x		x	x		
Domain Analysis Process Model (DAPM) [Sof91c]	STARS	process	x			x	x	x
Reuse Library Framework (RLF) [Sof93b]	STARS	tool				x	x	x
Reusability Guidelines [Sof89]	STARS	process				x		
ASSET Operations Plan [Ass92a]	ASSET	process					x	
Criteria and Process to Evaluate Assets [Ass92b]	ASSET	process					x	

B.2 Non-STARS Products

			Reuse Management			Reuse Engineering		
Product	*Source*	*Type*	*Plan*	*Enact*	*Learn*	*Create*	*Manage*	*Utilize*
DoD Software Reuse Vision and Strategy [DoD92]	DoD	process	x					
Direction Level Handbook [Cen93a]	CARDS	process	x					
Acquisition Handbook [Cen92]	CARDS	process	x					
Franchise Plan [Cen93b]	CARDS	process	x					
Reuse Adoption Guidebook [Vir92b]	VCOE	process	x		x			
Reuse Maturity Framework [KH91]	Harris	process	x					
Software Reuse: Guidelines and Methods [HC91]	Hooper/ Chester	process	x			x	x	x
DSSA Process Life Cycle [GTE92]	GTE/SEI	process	x		x	x	x	x
Reuse-Based Software Development Methodology [KCH+92]	SEI	process	x					
Process for Acquiring Software Architecture [SHM92]	MITRE	process	x			x		
Domain Engineering Guidebook [Vir92a]	VCOE	process	x			x	x	x
Domain Analysis and Design Process [DIS93]	DISA/CIM	process				x		
Feature-Oriented Domain Analysis (FODA) [KCH+90]	SEI	process				x		
JIAWG Object-Oriented Domain Analysis (JODA) [Hol92]	JIAWG	process				x		
Library Interconnect Language Annotated Ada (LILEANNA) [Tra90]	Tracz	process				x		x
KAPTUR [Bai89]	CTA	tool				x		x
Inquisix	SPS	tool				x	x	x
Reusability Search Expert (ReuSE)	Westinghouse	tool					x	x
Defense Software Repository System (DSRS)	DISA/CIM	tool					x	x
Universal Network Architecture Services (UNAS)	TRW	tool				x		x
Strategic Networked Applications Platform (SNAP)	Template Software	tool				x		x
Transportability Guideline for Ada Real-Time Software [Lab89]	CECOM	process				x		
Real-Time Requirements Annex for Ada Reusability [Com90]	CECOM	process				x		
An Approach for Constructing Reusable Software Components in Ada [Edw90]	IDA	process				x		
Ada Style Guide [Sof91a]	SPC	process				x		
Library Operation Policies and Procedures [Cen93c]	CARDS	process					x	

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